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Genetic diversity of *Riptortus pedestris* (Hemiptera: Alydidae) populations in the Republic of Korea based on *COI* sequence

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*Riptortus pedestris* (Fabricius) has caused severe agricultural damage in Asian regions. To clarify genetic relationships among different populations of *R. pedestris* in Korea, 294 *COI* sequences were generated from 294 individual samples collected in 42 local regions. In total, 36 haplotypes were detected from the 294 *COI* sequences, and the genetic distances among the 42 local populations ranged from 0.00 % to 1.50 %. In the AMOVA results, a variability of more than 98 % was observed within populations, and the median joining (MJ) networks revealed that *R. pedestris* has expanded by crossing the nine geographical groups. Most of the samples shared one haplotype, H2; however, some samples obtained from the same regions displayed slight genetic differences. These results indicate that *R. pedestris* have undergone a series of genetic variations.

**Key words**: *COI* sequence, genetic differentiation, Korea, *Riptortus pedestris*

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Genetic Diversity of *Halyomorpha halys* (Hemiptera, Pentatomidae) in Korea and Comparison with *COI* Sequence Datasets from East Asia, Europe, and North America

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The brown marmorated stinkbug, *Halyomorpha halys*, is an invasive insect pest in North America and Europe that attacks crop species and causes substantial economic damage. To evaluate the genetic diversities and distributions of different *H. halys* populations in East Asia, North America, and Europe, *COI* sequences obtained from 79 new specimens from Korea and 10 from the USA were compared with 725 existing *COI* sequences. In total, 45 haplotypes were detected in populations from 10 countries. Sixteen haplotypes from Korea (H34–H49) and 2 from the USA (H50 and H51) were novel. Korean populations exhibited the 2nd highest diversity among the 10 countries, with only Greece exhibiting higher diversity. Haplotype H22 was prominent in Korea, H1 was prominent in China, Greece, Hungary, Italy, Canada, and USA, and H3 was prominent in France and Switzerland. Of the 18 haplotypes found in Korea, 1 was shared with China (H2) and 1 with Greece (H22). Haplotype diversity patterns showed that Korean populations were genetically distinct from populations in China, Europe, and North America. This suggested that populations in Europe and North America arose through multiple invasions from China and that (with the exception of Greece), Korean populations did not spread to other countries. This study represents a comprehensive analysis of *H. halys* populations in Korea and places these populations in a global context that includes other native populations in East Asia and invasive populations in Europe and North America.

**Key words**: Brown marmorated stink bug, genetic diversity, haplotype, *mitochondrial cytochrome oxidase I*
**P003**

Nomenclatural Changes of *Cacopsylla moiwasana* (Kuwayama, 1908) species group (Hemiptera: Psylloidea: Psyllidae) associated with *Sorbus* (Rosaceae)

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Nomenclatural changes are provided for *Sorbus*-feeding *Cacopsylla moiwasana* (Kuwayama, 1908) species group. Thirteen Palaearctic *Cacopsylla* species have been recorded from *Sorbus* L. (Rosaceae), and of these, seven species restricted to East Asia. Among the East Asian species, four Japanese species, i.e. *C. elegans* Inoue, 2004, *C. jezoensis* (Miyatake, 1963), *C. midoriae* (Miyatake, 1963) and *C. moiwasana* (Kuwayama, 1908), assigned to *C. moiwasana* species group. Above the latter three species very similar to each other, allopatrically distributed, and all or some of them could be synonymous. The present investigation of the type material resulted in confirmation that *Psylla jezoensis* and *P. midoriae* should be treated as junior synonym of *P. moiwasana*. The following synonyms are proposed: *Cacopsylla moiwasana* (Kuwayama, 1908) = *Psylla jezoensis* Miyatake, 1963, syn. nov., *Psylla midoriae* Miyatake, 1963, syn. nov. The species are newly recorded from Korea.

**Key words**: Psylloidea, Psyllidae, Sorbus, host plant, synonym, new record

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**P004**

Notes on two Tortricid moths (Lepidoptera: Tortricidae) from Korea: *Hendecaneura impar* (Walsingham, 1900) and *Rhopobota orbiculata* (Zhang, Li, et Wang, 2005)

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Recently the distribution of two tortricid moths, *Hendecaneura impar* (Walsingham, 1900) and *Rhopobota orbiculata* (Zhang, Li, et Wang, 2005) was reported from Korea (Kim et al. 2014; Kim et al 2015). Here, we discuss the external morphology including the male and female genitalia, life history including host plants and mitochondrial DNA data (CO1) of these two species.

**Key words**: Hendecaneura, Rhopobota, Tortricidae, Lepidoptera, Life history, Korea
P005

Study on the immature stages of a Korean endangered species, *Argynnis nerippe* (Lepidoptera : Nymphalidae)

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The developmental biology and morphological characteristics of the immature stages of *Argynnis nerippe* were studied in the laboratory using host plant, *Viola papilionacea*.

Dormancy of the first instar larvae was broken when exposed in summer-like conditions (25 ± 1°C and continuous illumination of 5000-7000 lux). Feeding began within 1-2 days after awakening.

This species has six larval stadia and individuals take ca. 60 days (excluding dormancy) to mature from egg to adult. Illustrations and descriptions of the various immature stages and their behaviors are provided.

**Key words :** biology, immature stages, *Argynnis nerippe*, endangered species

P006

*Mimemodes cribratus* (Reitter) (Coleoptera: Cucujoidea: Monotomidae) new to Korea and a key to Korean monotomid species

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The family Monotomidae Laporte includes about 240 species placed in 33 genera worldwide and five species in three genera have been recorded to date in the Korean Peninsula.

*Mimemodes* Reitter contains 15 species occurring worldwide including nine Palaearctic species, of which five are recorded in Japan. In the Korean Peninsula, the genus and a single species, *Mimemodes emmerichi* Mader, were first recorded by Kang *et al*.

In the present study, we report an additional Korean species of the genus, namely *Mimemodes cribratus* (Reitter). We provide a redescription, images of habitus and diagnostic characters of the species along with a key to Korean species of Monotomidae.

**Key words :** Coleoptera, Staphylinidae, Aleocharinae, Athetini, *Acrotona*, new species, Korea
P007

A new record of the genus *Lissodema* Curtis (Coleoptera: Tenebrionidea: Salpingidae) with description of a new species in Korea

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While working on beetles collected by using flight interception trap, we found specimens possessing similar characters with salpingidine genus *Lissodema* Curtis. After detailed examination of the specimens and comparison with other *Lissodema* species, we concluded that these specimens represent a new species of the genus.

The genus *Lissodema* was first proposed by Curtis based on *Lissodema heyana* Curtis and contains 19 species in the Palaearctic region. In eastern Asia, 14 and three species are recorded in Japan and Russian Far East, respectively, but no species have been reported from Korea.

In this study, a description, habitus photographs and line drawings of diagnostic characters of a new species from Korea are provided.

**Key words**: Coleoptera, Salpingidae, *Lissodema*, new species, Korea

P008

Development of a Lucid key for Quarantine Macro-Lepidopteran pests in Korea

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The Lucid technology as an interactive fully illustrated identification tool, has developed and assisted in the diagnosis of agricultural and quarantine pests and invasive organisms over the past years. In this study, lepidopterans specifically relating to quarantine pests were selected for a lucid key development based on the border inspection data from 1996 to 2016 in South Korea. They belong to four families: Sphingidae, Noctuidae, Pyralidae and Crambidae, and also categorize into the three groups: regulated, potential regulated and non-quarantine pests. The key includes diagnostic characters from head, thorax, fore- and hind-wings for each species examined.

**Key words**: lucid key, quarantine pest, inspection data, Lepidoptera
Two newly recorded species of the genus *Centistes* Haliday (Hymenoptera: Braconidae: Euphorinae) in Korea

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The genus *Centistes* Haliday is a cosmopolitan group, comprising 89 species (Yu et al., 2016; Aguirre et al., 2017). Among them 41 species have been known from the East Palaearctic region (Yu et al., 2016). *Centistes* are known to be solitary koinobiont endoparasitoids of final instar larvae (rarely) and Coleopteran adults, particularly the families Anthicidae, Carabidae, Chrysomelidae, Coccinellidae, Curculionidae, and Staphylinidae (Loan, 1964; 1972; Shaw, 1985; Chen and Achterberg, 1997). Previously, 16 Korean species of the genus have been investigated by several researchers (Papp, 1994; Belokobylskij, 2000a; 200b; Ku et al., 2001; Lee et al., 2016). In this study, two species of *Centistes* are reported for the first time from Korea: *Centistes minutus* Chen & Achterberg, *C. sylvicola* Belokobylskij. Diagnosis and photographs are provided for each species.

**Key words**: *Centistes*, Braconidae, Hymenoptera, new record, Korea

Taxonomic review of genus *Coccura* (Hemiptera: Pseudococcidae) from Korea

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Two species of the genus *Coccura* Šulc, 1908 from Korea are reviewed. *Coccura convexa* Borchsenius, 1949 and *C. suwakoensis* (Kuwana and Toyoda, 1915) were recorded from North Korea by the report of Danzig (1980). Although Kwon et al. (2003) described *Coccura comari* (Kunow, 1880) from South Korea, we found that this species was misidentification of *C. suwakoensis*. In this study, we suggest that *Coccura comari* (Kunow, 1880) is to be excluded from the Korean fauna. The occurrence of *C. suwakoensis* is also recorded from South Korea for the first time, based on the additional populations which were heavily infested on the Chinese fingetree, *Chionanthus retusus* Lindley and Paxton. A key to the species of *Coccura* known from Korea is provided with diagnoses and photographs.

**Key words**: phenacoccinae, misidentification, taxonomy
A taxonomic review of Genus *Microrhagus* (Coleoptera: Eucnemidae) from Korea

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The genus *Microrhagus* Dejean, 1833 is reviewed with four species from Korea: *Microrhagus foveolatus* (Fleutiaux, 1923), *Microrhagus jejuensis* sp. nov., *Microrhagus mystagogus* (Fleutiaux, 1923), and *Microrhagus ramosus* Fleutiaux, 1902. Herein, we provide a key to species of Korean *Microrhagus*, with diagnoses and photographs for each species.

**Key words:** Taxonomy, Eucnemidae, Microrhagus, New record, Korea

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First report of an intercepted *Craspedoxantha marginalis* on *Phaenocoma prolifera*, which was imported from South Africa, under the plant quarantine inspection in Korea

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*Craspedoxantha* genus has been distributed in worldwide as 7 species in Afrotropical and 2 species in Oriental Regions. It is generally known that *C. marginalis* is preferred Asteraceae including *Vernonia* spp. for host plant. However, *C. marginalis* was first found in cut-flower of *Phaenocoma prolifera*, which was imported from South Africa, under the plant quarantine inspection in Korea. Therefore, we first report that *P. prolifera* as a new host plant for *C. marginalis* and provide information of the morphological characteristics and DNA barcoding sequences on male and female for identification.

**Key words:** *Craspedoxantha marginalis*, *Phaenocoma prolifera*, South Africa, Plant quarantine, New host plant
P013

First Record of Genus *Ulmica* Kerzhner (Heteroptera: Miridae: Orthotylinae) in Korean Peninsula

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The orthotyline plant bug genus *Ulmica* is reported from Korean peninsula for the first time with one new species, *Ulmica* sp. sp. nov. Morphological diagnosis, the dorsal habitus and genitalia of both sexes are figured for new species. A key to the world *Ulmica* species is also provided to aid in their identification.

**Key words** : Miridae, Orthotylinae, Orthotylini, *Ulmica*, Korean peninsula, new species.

P014

Two newly recorded species of the genus *Nemapogon* Schrank (Lepidoptera, Tineidae) from Korea

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Some species of the genus *Nemapogon* Schrank, 1802 (*N. granella*, *N. cloacella*, and *N. variatella*) are well known as storage pests and distributed worldwide (Gaedike, 2000). The larvae of these moths feed on stored food such as cereals, flour, and dried mushrooms (Robinson and Nielsen, 1993).

In Korea, the genus *Nemapogon* have been reported only one species up to date (Byun et al., 2009), with *Nemapogon granella* (Linnaeus, 1758).

In this study, two additional species of the genus *Nemapogon* Schrank are reported for the first time in Korea. The adults are briefly described and illustrated, including adults genitalia.

**Key words** : Tineidae, *Nemapogon*, storage pests, new records, Korea.
Pictorial Key of Subfamily Nitidulinae Latreille, 1802 (Coleoptera: Nitidulidae) from Korea

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The subfamily Nitidulinae in Korea is reviewed with a pictorial key to species. In total, 30 species of 18 genera are recognized including three newly recorded genera, each with one species respectively: *Nitidula rufipes* (Linnaeus, 1767), *Stelidota multiguttata* Reitter, 1877 and *Hebasculinus japonus* (Reitter, 1877). Pictorial key to tribes, genera and species with illustrations of habitus are provided.

**Key words**: Cucujoidea, Nitidulidae, Nitidulinae, New record, Pictorial key

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Coniopteryx pallescens and Conwentzia sinica (Neuroptera: Coniopterygidae), new to Korea

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Coniopteryginae is a highly diversified group of Coniopterygidae. In Korea, only two species, *Semidalis aleyrodiformis* and *Conwentzia pineticola*, are recorded. Here we report two additional species of Coniopteryginae, *Coniopteryx pallescens* and *Conwentzia sinica*, as new records in Korea. Brief descriptions, photos of adults and male genitalia as well as COI barcode sequences are provided.

**Key words**: Coniopteryginae, Korean fauna, new record
Overview of the family Nolidae (Lepidoptera: Noctuoidea) from Korea

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The family Nolidae belongs to the superfamily Noctuoidea comprising about 1,800 described species of 186 genera in the world. In China, a total of 101 species, 45 genera were recorded in ‘Fauna Sinica’ Vol.16, (1999) and in case of Japan, 110 species, 42 genera have been recorded in ‘The Standard Moth of Japan II’, (2011).

In Korea, a taxonomic study of this family has been carried out by several researchers: Fixsen (1887), Leech (1888), Inoue (1976, 1982), Oh (2001), Sohn et al (2005), Choi (2006, 2011). However, the family Nolidae has rarely been studied in Korea. A total 45 species, 25 genera have been reported from Korea (NIBR, 2016). In the present study, we overviewed the family Nolidae, with illustrations of adults in each genus, and checklist.

Key words : Lepidoptera, Noctuoidea, Nolidae, Overview, Palearctic region, Korea

First record of gyne fossil Aphaenogaster (Hymenoptera: Formicidae: Myrmicinae) from Eastern Palearctic Region

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We report here the new species, Aphaenogaster koreana sp. nov. first fossil record of alate reproductive female (gyne) Aphaenogaster from Eastern Palearctic region on the basis of forewing venation and other external morphologies. Single fossil specimen was discovered from the Duho Formation of the Middle Miocene (c.a 15 Ma), Pohang, Republic of Korea. For accurate identification, we selected extant Aphaenogaster species for reference and compared wing venations and body measurements to new species. Furthermore, we suggest previously recorded Aphaenogaster species from Miocene Grubstake Formation of Alaska (UAF-GS23, UAF-GS24) removed from the genus and remained in unplaced species in the Myrmicinae (incerta sedis). Because of similarity between genus Aphaenogaster and Paraphaenogaster which shares morphological similarities, we provide comparison between the new species and the other known gyne Aphaenogaster and Paraphaenogaster. Diagnostic characters for gynes of Aphaenogaster are also provided.

Key words : Aphaenogaster, fossil ant, Miocene, new species, Korea
Two newly recorded of the genus *Stigmella* Schrank (Lepidoptera: Nepticulidae) from Korea

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The genus *Stigmella* is one of the largest group in the family Nepticulidae (Lepidoptera: Neticuloidea), comprising 428 described species in the world. In Korea, totally eight species have been known to date so far we know. Recently two newly recorded species are collected from Gwangneung forest, Gyeonggi province, Korea. This study is aimed to report two species, *S. omelkoi* Puplesis, 1984 and *S. kurokoi* Puplesis, 1984, for the first time from Korea. These two species have been known as mining on *Quercus* (Fagaceae) in larva stage. We provide specific diagnosis, illustration of diagnostic characters for each species with available information including collection locality, host plant and distribution range.

**Key words**: Nepticulidae, *Stigmella*, leafminer, new records, Korea

First report of the subfamily Cybalomiinae Marion, 1955 (Lepidoptera, Crambidae) in Korea

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Cybalomiinae is a small subfamily of the family Crambidae, reporting 18 genera, 122 species in the world. However, this subfamily of species are still included in subfamily Pyraustinae in Korea with two species: *Trichophysetis cretacea* (Butler, 1879) and *T. rufoterminalis* (Christoph, 1881). Recently, these species transferred to Cybalomiinae by Shaffer *et al.* (1996). However, it was not considered in Korea.

In the present study, we report the subfamily Cybalomiinae from Korea for the first time, with a newly recorded genus. Illustrations of adults, male and female genitalia, diagnosis, description are provided.

**Key words**: Crambidae, Cybalomiinae, Pyraustinae, Korea
Species diversity of Spilomelinae moths (Lepidoptera: Crambidae) from Laos

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Laos is located in mainland of Southeast Asia, covered with 236,800 square kilometers. This country is located at the heart of the Indo-Chinese Peninsula and is surrounded by Myanmar, Thailand, Cambodia, Vietnam and China, providing a potential for a resource base and land-link in the Greater Mekong Sub-region.

Spilomelinae described over 3,800 species in the world, but Species diversity of Spiloemlinae moths were recorded only seven species in Laos by Shubhalaxmi (2011), Mally (2015) and Park et al. (2017). In this study, we provided seven species of illustrations and basic data on Laotian moth research.

Key words : Lepidoptera, Crambidae, Spilomelinae, Oriental region, Laos

Checklist of the Family Tischeriidae (Lepidoptera, Tischerioidea) from Korea, with a newly recorded species

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The family Tischeriidae belongs to superfamily Tischerioidea, comprising four genera and 115 species. Tischeriidae is known as a leafminer, Tischeriid larvae feed between the leaves of the host plants through all instars.

In Korea, two genera and four species have been recorded. recently, Sohn (2007) reported one species and Byun et al. (2009) arranged checklist of Tischeriidae.

In the present study, we provided checklist of this family, including a newly recorded species from Korea. Brief descriptions of species and illustration of adult and genitalia are provided.

Key words : Lepidoptera, Tischeriidae, taxonomy, Korea
Taxonomic review on the subspecies of *Eucarabus (Parhomopterus) sternbergi* (Coeloptera: Carabidae) from South Korea

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Until now, 12 subspecies of *Eucarabus (Parhomopterus) sternbergi* has been recorded in South Korea and some were described by foreign entomologist without comparative examination. In addition, most of them were not reviewed since the original description. Therefore, based on this study, all subspecies of this group in South Korea were revised taxonomically, and a new subspecific key was provided. As a result, 8 subspecies of *Eucarabus (Parhomopterus) sternbergi* were confirmed in South Korea and their new synonyms are as follows: *Eucarabus (Parhomopterus) sternbergi sternbergi* (Roeschke, 1898) = *E. (P.) s. gimhwa* (Rapuzzi, 2015); *E. (P.) s. honamensis* (Kwon et Lee, 1984) = *E. (P.) s. jindoensis* (Rapuzzi, 2015) = *E. (P.) s. goheungicus* (Rapuzzi, 2015); *E. (P.) s. schnelli* (Lassalle, 1999) = *E. (P.) s. deogyusan* (Rapuzzi, 2015).

**Key words**: *Eucarabus, Parhomopterus, sternbergi, Carabidae, Korea*

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Frist discovery of the family Meessiidae (Lepidoptera: Tineoidea) from Korea

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본 연구를 통해 나비목(Lepidoptera) 곡식좀나방상과(Tineoidea)내에 속하는 곡식좀나방붙이과*(Meessiidae)*의 국내 분포가 새롭게 확인되어 보고한다. 또한 곡식좀나방붙이과 점박이좀나방붙이속*(genus Eudarcia)*의 신종후보 3종 및 한국미기록 1종에 대한 상충, 생식기 특징과 국내 분포 등 이용 가능한 다양한 정보를 작성 및 제공하는 바이다.

*신칭

검색어 : 나비목, 곡식좀나방붙이과, 점박이좀나방붙이속, 신종후보종, 한국미기록종
Three species of the genus Yponomeuta Latreille, [1796] (Lepidoptera, Yponomeutidae) new to Korea

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The genus Yponomeuta Latreille belongs to the family Yponomeutidae, with over 75 described species worldwide. This genus is distributed mainly in the Palaearctic Region, comprising 42 species. In Korea, a total of 16 species have been reported from Korea. This genus is reported by Park (1983), with seven species in Illustrated Flora & Fauna of Korea Vol. 27. Bae & Byun (2003) reported four newly recorded species of this genus: Yponomeuta kanaella, Y. montanatus, Y. sociatus, and Y. yanagawanus. Byun (2009) listed a Korean Micro-Lepidoptera, recording 12 Yponomeuta species, with a newly recorded species Y. solitariellus. Sohn et al. (2010) and Lee & Park (2016) added two species: Y. anatolicus and Y. cinefacta.

In the present study, we reported three newly recorded species of Yponomeuta, including adults and genital photographs, host plants, distribution and short descriptions.

Key words : Lepidoptera, Yponomeuta, Taxonomy, new record, Korea

Review of Silvanidae (Monanus sp.) related Quarantine

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지난 18년간(2000~2018년 3월) 검역현장에서 검출된 해충의 종류는 1,980종이다. 이중 딱정벌레목은 전체의 42.6%(곤충은 1,707종으로 86.2%)로 검역적으로 매우 중요하며, 여기에서 가는납작벌레과(Silvanidae)는 딱정벌레목 머리대장상과에 포함되고, 이들의 검출 종은 21종, 횟수는 15,516회로 가장 많은 비율을 차지한다. 최근 18년간 검출물 결과 Ahasverus sdvana(쌀머리대장)로 6,404회로 가장 많이 검출되었으며, Silvanus didentatus(두니가는납작벌레)는 6,225회, Oryzaephilus surinamensis(머리대장가는납작벌레)는 1,123회, Oryzaephilus mercator(곡물가는납작벌레)는 415회의 검출률을 보여준다. 가는납작벌레과는 딱정벌레목중 가장많은 검출률을 보이는 과로 검역현장에서 매우 중요한 과에 속한다. 본 연구는 검역과정에서 검출되는 가는납작벌레과 곤충 중 검역현장에서 최초로 발견된 Monanus 속의 한 종을 발견하여 보고 한다.

검색어 : 가는납작벌레과, Monanus sp, Ahasverus sdvana, Silvanus didentatus, Oryzaephilus surinamensis, Oryzaephilus mercator, Quarantine
A New Record of the Species *Corticaria elongata* (Gyllenhal, 1827) (Coleoptera : Lathridiidae) from Korea

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국내 미기록종인 *Corticaria elongata* (Gyllenhal, 1827)는 막정벌레목(Coleoptera), 섬벌레과(Lathridiidae)에 속하는 종으로 유럽과 북아프리카, 아프카니스탄, 네팔, 파키스탄, 터키, 인도, 러시아, 중국, 일본 등에 서식하고 있는 것으로 기록되어 있고 국내에는 전북 완주군에서 2015년 8월에 처음으로 채집되었다. 크기는 1.49mm이며 폭은 0.6mm이고, 높이는 0.34mm이다. 긴 타원형 모양이며 양쪽 측면은 평행에 가깝고, 등면은 적당히 숟아올랐다. 몸 색깔은 연한 갈색 혹은 짙은 노란색이고, 더듬이와 다리의 연한 노란색이다. 표피는 부드러운 털로 덮여있으며 털은 길고 기르어져있다.

검색어: *Corticaria elongata*, 막정벌레목(Coleoptera), 섬벌레과(Lathridiidae), 미기록종

Insect Fauna of Seven Specific Islands in Korea

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환경부 지정 보호지역인 특정도서는 현재 249개소로 이들을 대상으로 지형, 지질, 식생, 동물, 해양수생 및 해안무척추동물, 해조류 분류군 대상으로 1차 특정도서기본계획(05~14) 이후 2차 특정기본계획(15~24)에 따라 매년 10~15개씩 정밀조사가 수행되고 있다. 특정도서의 곤충조사는 2006~2008년 3년간 39개 도서를 제외하고 전무하였다. 특정도서의 지정사유 중 자연경관, 지질의 우수성이 가장 높고 식생이 우수가 다음으로 높아 시간이 지남에 따라 식생과 관련된 해충 및 외래종의 기착지로 이용될 수 있는 특성을 가지고 있어 2015년부터 곤충에 대한 조사가 이루어지고 있다.

본 연구는 2016년 인천광역시 옹진군 일대 소초지도, 신도, 어평도, 항도, 몽등도, 서만도, 함미열 7개 특정도서에 대한 곤충종 및 군집분석 결과와 각 도서별 과거 2007년 보고된 곤충상을 비교한 결과를 보고하는 바이다.

검색어: 특정도서, 곤충상, 변화, 한국
Taxonomic review of the genus *Stenocranus* from the Korean Peninsula (Hemiptera: Auchenorrhyncha: Delphacidae)

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Delphacidae is the most diverse group in the Superfamily Fulgoroidea (Hemiptera: Auchenorrhyncha: Fulgoromorpha) with more than 2000 reported species worldwide. This group is commonly called planthoppers, because most members are grass-feeding species. Some members are known as vectors of economically important plant viruses, and damage to several crops in many countries.

*Stenocranus* is one of the biggest groups in the Delphacidae. In Korea, there have been eight recorded species. In this presentation, we present taxonomic review of the *Stenocranus* with a new record in Korea. Morphological characters and key to Korean species are presented.

**Key words:** Delphacidae, new record, Korean Peninsula, *Stenocranus*, taxonomy

Review of family Machaerotidae (Stål) (Hemiptera: Auchenorrhyncha: Cicadomorpha: Cercopoidea) in Korea

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The family, Machaerotidae (Stål), called tube-making spittlebugs, (Hemiptera: Auchenorrhyncha: Cicadomorpha) four tribes, 31 genera and 115 species in the world, and is mainly distributed in the Oriental and Palaearctic Regions. In Korea, two species, *Makiptyelus dimorphus* (Maki, 1914) and *Taihorina geisha* (Schumacher, 1915) have been recorded. This group have unique morphological characters as follows: Scutellum stretched, spine-like, flat or with sharp carinae and projections, longer than pronotum and forewing distinctly membranous or transparent. Additionally, nymphs make a calcareous tube using some woody dicotyledons and immerses itself in a rather clear fluid excretion inside the tube. In this presentation, the family Machaerotiade is reviewed in Korea. Morphological data, shape of calcareous tube, biological notes, and the key to Korean Machaerotidae species are presented.

**Key words:** Auchenorrhyncha, Hemiptera, Korea, Machaerotidae, review
**P031**

Checklist of the genus *Glaucocharis* Meyrick (Lepidoptera: Crambinae) with three newly recorded species of Korea

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Three species of the genus *Glaucocharis* Meyrick (Lepidoptera, Crambinae) are reported for the first time from Korea: *G. melistoma* (Meyrick), *G. rosannoides* (Bleszynski), and *G. vermeeri* (Bleszynski). The description, distribution, image of the adults, males, and females genitalia are provided. Also, checklist of the genus *Glaucocharis* from Korea is present.

**Key words**: Lepidoptera, Crambinae, *Glaucocharis*, new records, Korea

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**P032**

New record of a helconid wasp, *Schizoprymnus terebralis* (Hymenoptera: Braconidae), from Korea

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One species of the genus *Schizoprymnus* (Hymenoptera: Braconidae: Helconinae) is reported in this study. The genus *Schizoprymnus* is a braconid group distributed in the Palaearctic and Oriental regions, which include currently nine species in South Korea. In this study, *Schizoprymnus terebralis* Snoflk, 1953 is recognized for the first time in South Korea. Descriptions, diagnosis distribution and illustration are provided.

**Keywords**: Braconidae, Hymenoptera, New record, parasitoid wasp, *Schizoprymnus*
New records of Limacodidae (Lepidoptera, Zygaenoidea) from Korea

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Limacodidae, also known as slug moths, comprise about 1,000 species worldwide (Epstein et al., 1998). This moth group is characterized by two adult characteristics: the presence of the female legs with the recessed pad of sensilla trichodea underneath and the entire, disk-shaped papillae anales, and four characteristics in immature stages: the absence of the crochets in all instars of larvae; the presence of the extended pupal maxilla, contiguous with the labial palpus; the hard, ovoid cocoons, lid invisible when uneclosed; and the flat, thin eggs (Epstein, 1996). Since Fixsen (1887), a total of 19 genera and 26 species of Limacodidae have been recorded from Korea. In the present paper, we reported three species of Limacodidae new to the Korean fauna: \textit{Ceratonema butleri} Kawada, 1930, \textit{Microleon decolatus} Sasaki, 2016, and \textit{Isopenthocrates japonae} Yoshimoto, 2004.

Key words: Lepidoptera, Limacodidae, new records, taxonomy

Pygmy moth leaf-mine fossil (Lepidoptera, Nepticulidae) on \textit{Fagus} (Fagaceae) from the Miocene Geumgwangdong Formation, Pohang Basin, Korea

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A nepticulid leaf-mine ichnofossil is described on the basis of a fossil leaf of \textit{Fagus} from the early Miocene Geumgwangdong Formation (ca. 21–14 million years ago) in Pohang basin. This mine trace is characterized by a linear-blotch type with clear centric frass trail of closely and randomly dispersed pellets filling the mine width in early stage. We found traces of possible egg case and exit slit from the fossil. These features are most consistent with those produced by Nepticulidae. Our record represents the only reliably-identified nepticulid leaf-mine on \textit{Fagus} in Miocene. Nepticulid leaf-mines in Miocene and the leaf-mine fossils from the Geumgwangdong Formation are briefly reviewed.

Key words: Fagus, Leaf-mine fossil, Lepidoptera, Miocene, Nepticulidae
Addional Mitochondrial DNA Sequences from the Dung Beetle, *Copris tripartitus* (Coleoptera: Scarabaeidae), Which Is Endangered in South Korea

**Eun Ju Hwang, Su Yeon Jeong, Ah Rha Wang, Min Jee Kim and Iksoo Kim**
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Previously, a partial mitochondrial COI and CytB gene sequences have been used to infer genetic diversity and gene flow of the species. In this study, we additionally collected *C. tripartitus* from one previous and two new localities, sequenced the COI and CytB genes. Sequence divergence of current samples showed slightly lower values, but nearly equivalent to previous study. Haplotype diversity was still high and nucleotide diversity indicating that Seogwi-dong showed the highest estimates in both gene sequences. Gene flow among populations is high, but a significance difference was detected between Gulupdo and Anmado; and between Gulupdo and Seogwi-dong only in COI sequences ($P < 0.05$). Considering the high genetic diversity and gene flow in *C. tripartitus* populations, one of the major issues regarding conservation seems not to be the recovery of genetic diversity as has been suggested before.

**Key words :** dung beetle, *Copris tripartitus*, COI, CytB, geographic variation, genetic diversity

Complete Mitochondrial Genomes of Four Geometrid Moths and Phylogenetic Positions of Geometroidea in Macroheterocera

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Previous phylogenetic results often showed fluctuating positions of Geometroidea in Macroheterocera, particularly from mitochondrial genome (mitogenome)-based analyses. In this study, we sequenced mitogenomes of four geometrid moths to increase taxon diversity for the inference of phylogenetic positions of Geometroidea in Macroheterocera. The general genomic features found in Macroheterocera also were found in the four geometrid moths. Phylogenetic analyses using 71 representative mitogeneome sequences in Macroheterocera yielded the consensus superfamilial relationships (((Bombycoidea + Lasiocampoidea) + Geometroidea) + Noctuoidea) + Drepanoidea) + Mimallonoida), confirming the sister relationship of Geometroidea to (Bombycoidea + Lasiocampoidea) in both Bayesian Inference and Maximum-likelihood method.

**Key words :** Geometroidea, Macroheterocera, complete mitochondrial genomes, phylogeny
P037

Complete Mitochondrial Genome Sequence of *Acoptolabrus changeonleei* Ishikawa et Kim, 1983 (Coleoptera: Carabidae)

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The *Acoptolabrus changeonleei* Ishikawa et Kim, 1983 (Coleoptera: Carabidae), has been listed as an endangered insect in South Korea. The complete mitochondrial genome of the species was 16,831 bp with a typical set of genes (13 protein-coding genes [PCGs], 2 rRNA genes, and 22 tRNA genes) and one non-coding region, with the arrangement identical to that observed in most insect genomes. Phylogenetic analyses with concatenated sequences of the 13 PCGs and 2 rRNA genes, using the Bayesian inference (BI) and maximum-likelihood (ML) methods, placed *A. changeonleei* as a sister to the within-subfamilial species *Damaster mirabilissimus* in Carabinae, with the highest nodal support by both analyses.

**Key words:** mitochondrial genome, Carabidae, *Acoptolabrus changeonleei*, endangered species, phylogeny

P038

Development and Validation of Microsatellite Markers for the Tiny Dragonfly, *Nannophya pygmaea* (Odonata: Libellulidae), Which Is Endangered in South Korea

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In this study, we developed 12 microsatellite markers specific to *N. pygmaea* using Illumina paired-end sequencing. Forty individuals of *N. pygmaea* collected from three currently known localities in South Korea were genotyped to validate these markers and to preliminarily assess population genetic characteristics. No locus showed significant deviation from the Hardy–Weinberg equilibrium (HWE). Our preliminary data indicate an absence of inbreeding in all populations and an absence of obvious genetic difference. The microsatellite markers developed in this study will be useful for studying the population genetics of *N. pygmaea* collected from other regions, including additional sites in South Korea.

**Key words:** *Nannophya pygmaea*, microsatellite marker, illumina paired-end sequencing, endangered species
Three newly recorded species of the tribe Ephialtini (Hymenoptera: Ichneumonidae: Pimplinae) from South Korea

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The subfamily Pimplinae currently include 1,737 worldwide species in 77 genera. 78 species in 21 genera have been recorded from South Korea. Among them, the genera Exeristes, Gregopimpla and Paraperithous are small groups with 10, 8 and 6 species from worldwide. The existing South Korean Exeristes and Paraperithous include only one species, E. roborator (Fabricius) and P. chui (Uchida). Three species of genus Gregopimpla have been recorded from South Korea, G. himalayensis (Cameron), G. inquisitor (Scopoli) and G. kuwanae (Viereck).

In this study, we report three newly recorded species Exeristes longiseta (Ratzeburg), Gregopimpla ussuriensis Kasparyan and Paraperithous gnathaulax (Thomson) from South Korea, including diagnoses, photographs of newly recorded species and keys to the species of South Korean Exeristes, Gregopimpla and Paraperithous.

Key words: Exeristes, Gregopimpla, Paraperithous, South Korea, taxonomy

First record of the monotypic genus Harpiphorus Hartig (Hymenoptera: Tenthredinidae: Allantinae) from South Korea

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Harpiphorus, a monotypic genus of subfamily Allantinae (Symphyta: Tenthredinidae), was established based on Tenthredo (Emphytus) lepida Klug. The genus is close to Hemibeleses Takeuchi but can be easily distinguished by the following characteristics: the cell 1M in fore wing with a distinct petiole dorsally and cell M in hind wing closed. Harpiphorus is widely distributed in Europe, but has not yet been found in outside the continent. The larva of this genus is phytophagous attacking the oak species (Quercus trojana Webb and Q. robur L.).

As a result of the present study, the genus Harpiphorus is reported based on H. lepidus for the first time from South Korea and the Eastern Palaearctic region. A diagnosis, figures of morphological features are provided.

Key words: Eastern Palaearctic, new distribution record, Symphyta, taxonomy
First Record of the Genus Tineobius Ashmead (Hymenoptera: Chalcidoidea: Eupelmidae) from South Korea

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Tineobius Ashmead, 1896 is a relatively small group in the family Eupelmidae. It can be distinguished by the following characters: head with conspicuously lengthened maxillary palpus, mesotibia without apical groove, gaster with deeply emarginate syntergum and filiform ovipositor sheaths.

Most species of Tineobius were recorded from Afrotropical, Australasian and Oriental region. However, in Palearctic region, only one species (Tineobius tamaricis Ribes & Fusu) is discovered from Spain by Fusu & Ribes (2017).

In this study, the genus Tineobius is reported from South Korea for the first time, with two newly recorded species. Also, a key to South Korean species of Tienobius, diagnoses and photographs of the diagnostic characteristics are provided.

Key words: Eastern Palearctic, newly recorded species, Taxonomy

First Record of the Genus Hyperimerus Girault (Hymenoptera: Pteromalidae: Asaphinae) from South Korea with Taxonomic Note of Asaphes vulgaris Walker

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Asaphinae Ashmead, 1904 are the smallest subfamily in Pteromalidae and currently include 27 extant species of 6 genera. Up to date, only 2 species, Asaphes suspensus (Nees) and A. vulgaris Walker, have been recorded from South Korea. Among them A. vulgaris Walker is suspected of misidentified due to several reasons.

Hyperimerus Girault, a small genus of the subfamily Asaphinae, consists of two world-wide species. It is close to Asaphes Walker but is separated by the following characteristics: antenna with one anelliform segment; scutellar frenum not distinct; petiole transverse.

In this study, we report genus Hyperimerus based on Hyperimerus pusillus (Walker) for the first time from South Korea and Eastern Palearctic region. Also, a key to the genera of Asaphinae from South Korea, diagnosis, photographs of each species and taxonomic note of A. vulgaris Walker are provided.

Key words: Eastern Palearctic, taxonomy, A. vulgaris
**Poster Presentation**

**P043**

**Interactive key to New Zealand genera of the supertribe Faronitae using Lucid**

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개미사돈아과는 반날개과에서 두 번째로 큰 분류군이지만 다른 아과에 비해 연구가 가장 미흡한 분류군 중 하나이다. 개미사돈아과 내 다른 모든 아과의 자매군인 Faronitae상족은 비교적 작은 상족이며 최근 뉴질랜드 지역에서 종 수준의 포괄적인 재검토가 이루어졌다. 이를 바탕으로 Faronitae상족의 12속을 좀 더 쉽고 빠르게 동정하기 위하여 이미지를 활용한 interactive 분류기를 작성하였다. 분류기는 Lucid 3.3 builder를 사용하여 제작하였으며 총 36개의 형질과 134개의 형질상태를 사용하여 작성되었다. 이 프로그램은 현재 세계적으로 다양한 분야에서 사용되고 있는 식별키 프로그램이며, 제작 후 배포에도 용이하여 다른 연구자들에게도 정보를 제공할 수 있다. 이번 연구에서 포함된 속은 현재 뉴질랜드에 알려진 모든 속을 포함한다. 본 연구를 통하여 Faronitae상족에 대한 정보들을 제공하고, 웹 기반의 다양한 활용이 기대된다.

**검색어** : 개미사돈아과, Interactive key, Lucid, Faronitae

**P044**

**Henryana, an unrecorded genus of Tetrastichinae (Hymenoptera: Eulophidae)**

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*Henryana* Yoshimoto, 1983 is a rare genus in Tetrastichinae, Eulophidae with only one species known from USA and Brazil. A species of the genus is newly recognized in South Korea. The genus has peculiar characters for a tetrastichine species. The genus can be easily distinguished from other genera by following characters: head with postgenal sulcus and with strongly swollen gena; vertex extending much higher that dorsal margin of eye; submarginal vein with usually 3 short dorsal setae that are in distinct contrast to the very long setae on marginal vein; entire body extremely elongated. Images and description of diagnostic characters are given in the present study.

**Key words** : Henryana, Tetrastichinae, Eulophidae, new record, South Korea
Some new and newly recorded species of the family Gracillariidae (Lepidoptera) to Korea

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The family Gracillariidae are known as ‘leaf-miners’ comprising 1,966 described species of 106 genera in the world. In Korea, there are 3 subfamily, 14 genera of 58 described species to date. In this study, some new and newly recorded species of the family Gracillariidae were recorded for the first time in Korea. Also, all the available information including synonym list, images for adult and genitalia and distributional ranges were provided.

Key words: Leafminer, Gracillariidae, Lepidoptera, new species, newly record

A new species with newly recorded genus Docirava Walker, [1863] (Lepidoptera: Geometridae) to Korea

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The genus Docirava Walker, [1863] belongs to the tribe Chesidiini of the family Geometridae with only 12 described species in the world. The genus could be distinguished from other genera of Chesidiini with the characters, which had been described by walker in original description as follow: “Proboscis slender, rather long….Legs long, very slender; hind tibiae with four rather short and slender spurs”. In this study, the genus Docirava was first recorded with a new species Docirava sp. nov. with DNA barcode. Also, all the available information including images for both of genitalia and adult, wing venation and descriptive study was provided.

Key words: Docirava, Larentiinae, Geometridae, Lepidoptera, new species
Analysis of intercepted pests on hand-carried plants in Korea during 2017

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Plant quarantine is preventing the introduction and adaption of exotic pests in homeland, and then eventually promoting and improving domestic agriculture and forestry. Therefore, we conducted a survey of intercepted pests on hand-carried plants from all over the world to Korea. Totally 7,291 of hand-carried plants had been inspected by quarantine inspectors at 2017. Gimpo, Daegu, and Incheon International Airport showed more inspection cases than other areas by November 10, 2017, meanwhile, Gimhae and Incheon International Airport and Incheon Harbor showed more intercepting pest rate than other areas. In Animal and Plant Quarantine Agency, inspector found 490 cases of intercepted pests on 32 countries including China with 116 imported goods.

Key words: Quarantine, Intercepted pest, Hand-carried plant, Animal and Plant Quarantine Agency

Korean species of the genus Cochylidia (Lepidoptera: Tortricidae) in Korea

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Genus Cochylidia, belonging to the tribe Cochylini under the family Tortricidae, consists of small-sized moths, which is one of the small group with only 11 described species until now (Brown 2005; Sun & Li 2012). Recently, Brown (2005) listed eight species and one subspecies. Later, three species were added to the genus by Sun & Li (2012) from China.

In Korea, Park (1976) reported the genus Cochylidia with three unrecorded species, C. contumescen Meyrick, C. richteriana Fischer von Röslerstamm, and C. subroseana Haworth from Korea. Later, Byun et al. (1996) reported two additional species from Korea: C. heydeniana Herrich-Schäffer and C. moguntiana Rösl. Recently Byun et al. (2017) reported the genus in Korea with two new species, C. flavifasciatus Byun and C. hallasanensis Byun. In this study, we provide the checklist with its external characteristics, localities, and images of adults and genitalia.

Key words: Cochylidia, Korea, Lepidoptera, Tortricidae
Korean species of the genus *Choristoneura* Lederer (Lepidoptera: Tortricidae)

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This study was conducted to clarify the faunistic information of the genus *Choristoneura* in Korea. The genus *Choristoneura* belongs to the tribe Archipini of the family Tortricidae, including 46 species in the world. Among them, *Choristoneura albaniana* (Walker) is the only one species with a Holarctic distribution (Dang, 1992; Fagua et al., 2014).

In Korea, 7 species of the genus *Choristoneura* have been reported up to date. But taxonomic location of some species in the genus are still confused: e.g. transfer of *Choristoneura evanidana* to *Archips; Choristoneura simonyi* to *Xenotemna* and so on. Also, it is necessary to identify correctly the genus *Choristoneura*, especially known as the forest pest. In this study, we rearrange and re-place the species, including nomenclatural changes according the current study.

**Key words**: *Choristoneura*, Tortricidae, Lepidoptera, leaf-roller, South Korea

Record of *Thrips setosus* Moulton (Thysanoptera: Thripidae) in Korea damaging to leaves of *Hydrangea*

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*Thrips setosus* Moulton, 1928 (Thysanoptera: Thripidae), one of the *Tospovirus* vectors, was found at a commercial greenhouse in Korea. It damaged to leaves of hydrangea (*Hydrangea macrophylla*). The thrips widely distributes in Japan, being regarded as its origin. Recently, it invaded in Europe such as the Netherlands, France, and Germany. Unlike Japan, it was found on *Hydrangea* plants in European countries. In Korea, the thrips was recorded in 1974 by Woo. However, examination of voucher specimens reveals that the record is not true. According to the collection data since 2000, its distribution in Korea is rarely limited in Jeonbuk and Jeju. For identification, representative morphological characteristics and *COI* barcoding results are provided with possibility of introduction from Europe.

**Key words**: *Thrips setosus*, *Tospovirus*, *Hydrangea*, pest
First record of *Aphelenchoides composticola* Franklin, 1957, associated with damage of mushroom in Korea

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*Aphelenchoides composticola* is an economic pest in mushroom cultivation, with a potential to cause heavy losses in the commercial production of Agaricus spp. Recently, *A. composticola* was intercepted on cultivated mushrooms in Korea and herein, this newly recorded species is morphologically and morphometrically characterized, and symptoms of mushroom damage are equally illustrated. The offset head, a prominent muscular median bulb, oval to round in shape, lateral field with three incisures, tapering truncate tail and average body length of 612.8μm, characterize females. Males are slightly smaller (561.2μm), characterized by well-developed paired spicules, ventrally curved tail, and conoid tail terminus posed with a terminal mucro.

**Key words**: Agaricus spp., *Aphelenchoides composticola*, mushroom, nematode

Investigation on the intercepted insects from prohibited plants by hand-carry

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2017년 한해 동안 9개 공항만에서 중국 등 32개국, 120개 품목 8,660건을 조사한 결과, 523건에서 해충 검출이 있었다. 반입빈도가 높은 품목은 사과, 망고, 감귤, 배, 복숭아, 바나나, 오렌지, 오이, 고추, 호두(미탈각), 자두, 드래곤프룻, 포멜로, 토마토, 뜨_TRIANGLES, 람부탄, 고추, 자두, 구아바 등이며, 해충 검출 빈도가 높은 국가는 중국, 비트남, 대만 등이었다.

검출 해충류 중 금지해충으로 오리엔탈과실파리류(*Bactrocera dorsalis* sp. complex) 52건, 오이과실파리(*Bactrocera cucurbitae*) 1건, *Bactrocera latifrons* 2건이 있었으며, 과실파리류 32건이 동정중이며, 코드나방(*Cydia pomonella*)이 1건 검출되었다.

**검색어**: 휴대반입, 금지식물, 해충, 검역
A new record of *Asca bicornis* Canestrini & Fanzago, 1887 from Mt Hallasan, Jeju, Korea

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Mites in the family Ascidae are predacious soil dwellers with potential of biological control of soil insect pests. The family Ascidae is comprised of 10 genera with 12 species recorded in Korea. During the soil acarine biodiversity study in Muljangori, Hallasan Mt in Jeju, *Asca bicornis* Canestrini & Fanzago, 1887 was discovered from moss habitat and are reporting this as a new record to Korean Mesostigmata fauna. We provide the illustration and description. This species has morphological characteristics of all dorsal setae nude and needle shaped, lateral caudal projection of PoZ4 shape which are different from the con-general species of *A. aphidioides*.

**Key words**: Taxonomy, first record, Ascidae, Muljangori-oreum, Jeju

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Investigation on the intercepted insects and prohibited-plants from Incheon Airport

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**검색어** : 인천공항, 휴대식물, 검역, 검역해충, 오리엔탈과실과리
The research of Classification and Identification for Quarantine Application of psyllids (Hemiptera : Stemorrhyncha: Psylloidea) Collected from Jeju-island

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Recently a colony of Solenopsis invicta, the red imported fire ant (RIFA), was intercepted on Gamman pier, Pusan port in Korea by Animal and Plant Quarantine Agency. It has been generally known that RIFA has two social forms as monogyne and polygyne, which showing the behavioral differences between the two forms and dictated by a pheromone binding protein, Gp-9. The social forms of the RIFA colony was revealed as polygyne form, when the GP-9 gene was analyzed by three allelic discrimination assays including Real-Time PCR (RT-PCR), rh-Amp SNP Genotyping, and peptide nucleic acid probe-based RT-PCR in this study.

Key words : Solenopsis invicta, Red imported fire ant, Pheromone binding protein, Gp-9 gene, Polygyne form
Molecular characterization of a red imported fire ant colony, *Solenopsis invicta* intercepted on Gamman pier of Pusan port in Korea by analysis of mitochondrial DNA gene

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A colony of *Solenopsis invicta* was first intercepted on Gamman pier, Pusan port in Korea at September, 2017 by Animal and Plant Quarantine Agency. The mitochondrial DNA (mt-DNA) of workers was analyzed and compared with vary libraries of mt-DNA haplotypes to elucidate the origin of the introduced colony with the trade pattern of the Gamman pier. The mt-DNA fragment of 768 bp, which is part of the *Cytochrome oxidase I* gene, was amplified and sequenced. The results showed that the mt-DNA was in the clade of haplotype 5, which is endemic in southern USA, China, Taiwan, and Australia. More than 60% of containers are imported from China into Gamman pier, it may be possible to assume that the colony was inadvertently invaded through containers from China.

**Key words**: *Solenopsis invicta*, Red imported fire ant, Mitochondrial DNA, Animal and Plant Quarantine Agency

Molecular and neural mechanisms on the avoidance behaviors of *Culex pipiens* to ultrasonic sounds

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Mosquitoes are transmit many dangerous disease such as malaria, yellow fever and dengue fever. So far, chemical insecticides such as DEET have been mainly used to control mosquitoes, but there are many side effects. This study used ultrasonic sounds as an alternative to chemical insecticides. We found that *Culex pipiens*, which are common in Korea, exhibit avoidance behavior in a specific ultrasonic frequency. Through electrophysiological recording, we have inferred that avoidance behavior is caused by different from each other mechanisms depending on the ultrasonic frequency. Using immunohistochemical staining, we analyzed the expression pattern of auditory related genes in the chordotonal organ. Quantitative real time-PCR was used to compare the expression levels of auditory related gene depending on the time of exposure to ultrasonic sounds.

**Key words**: Culex pipiens, ultrasonic sounds, avoidance behavior, auditory reponse
Acetylcholine titer is actively regulated by acetylcholinesterase and choline acetyltransferase in both the central and peripheral nervous systems

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The honey bee soluble acetylcholinesterase 1 (AmAChE1) is overexpressed under the overwintering and brood rearing-suppressed conditions. To investigate the role of AmAChE1 in regulating acetylcholine (ACh) titer, ACh concentrations in both the head (central nervous system) and abdomen (peripheral nervous system) were analyzed. ACh titer was significantly lower in both tissues of worker bees under the overwintering and brood rearing-suppressed conditions compared to control bees. Interestingly, the expression levels of choline acetyltransferase (AmChAT) and molecular marker genes of immune systems were significantly reduced in honey bee head under the same conditions. Taken together, ACh titer appears to be reduced via a cooperative interaction of the AmAChE1 overexpression and AmChAT underexpression and to be linked to reduced immune responses under the overwintering and brood rearing-suppressed conditions. The roles of AmAChE1 (with little catalytic activity) and AmChAT in the ACh homeostasis and signaling was discussed in the contexts of immune response and longevity regulation in honey bees.

Key words: Apis mellifera, acetylcholinesterase, choline acetyltransferase, acetylcholine, immune response, longevity

Estimation of seasonal and labor-dependent expression patterns of reference genes in honey bee heads for quantitative real-time PCR

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Honey bee has been widely used as a model insect for biological sciences because of its sociality and specialized labor division. For the investigation of the seasonal and labor-dependent expression patterns of genes putatively involved in its sociality, quantitative real-time PCR (qRT-PCR) can be applied to quantify gene expression level and selection of reliable reference gene(s) for normalization is an accurate step. In this study, using three softwares (geNorm, NormFinder and BestKeeper), we evaluated seasonal expression stabilities of four reference genes that have been widely used for qRT-PCR in forager and nurse heads. Among four candidates, two genes, rpS18 and gapdh, were suggested to be the optimal reference genes for qRT-PCR.

Key words: honey bee, qRT-PCR, reference gene, normalization
P061

Comparative study of chemical tolerance between *Drosophila melanogaster* and *Drosophila suzukii*

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*Drosophila melanogaster* and *Drosophila suzukii* are the species of the family Drosophilidae. Although these two fruit flies are taxonomically close species, *D. suzukii* is thought to be evolutionally adapted to the flesh or maturing fruits, whereas *D. melanogaster* is adapted to more fermented environments. According to the previous studies, several environmental toxins, such as acetic acid, ethanol, methanol and phenylacetate, etc., have been identified from rotten fruit and fermentation procedures. Considering the differences of distinct habitat between two flies, *D. melanogaster* is hypothesized to exhibit higher tolerance to the chemical toxins than *D. suzukii*. Therefore, in this study, we compared the tolerance and susceptibility of two fruit flies to three chemicals (acetic acid, ethanol, 2-phenylethano).

**key words:** *Drosophila melanogaster*, *Drosophila suzukii*, chemicals, adaptation, tolerance

P062

The whitening and moisturizing effect of the larvae of *Protaetia brevitarsis*

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Although the white-spotted flower chafers beetle, *Protaetia brevitarsis*, receive attention to explore useful active ingredient for the preventive effect of liver-related diseases, little is known about cosmetic effect. Here we report that the larva extract of the white-spotted flower chafers has functional cosmetic effect using the B16F10 melanoma cell and HaCaT keratinocyte cell. The ethanol extract of hot-air dried *P. brevitarsis* larvae showed the inhibitory activity of tyrosinase (an enzyme that regulates the melanin production) and remarkably inhibit melanin biosynthesis in the B16F10 melanoma cell. Further, the ethanol extract induced the expression of hyaluronic acid synthetase (HAS2/HAS3), which produce hyaluronan related to epidermal structure, and indeed increased hyaluronan in HaCaT keratinocyte cell. Consequently, *P. brevitarsis* could be new functional cosmetic material for whitening and moisturizing effect.

**Key words:** tyrosinase, melanin, hyaluronan, cosmetic effect
The effects of temperature on starvation resistance are context dependent in *Drosophila melanogaster*

**Taehwan Jang and Kwang Pum Lee**  
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Temperature can modulate how insects respond to environmental stressors, such as starvation. In this study, we examine whether and how the effects of temperature on starvation resistance depend on nutritional condition and developmental stages in *Drosophila melanogaster*. Starvation resistance decreased as the temperature exposed during starvation rose from 18 to 28 °C, which was mainly caused by warming-induced increase in energy expenditure. When exposed to warm temperatures during feeding, *D. melanogaster* accumulated more energy reserves and thus become more starvation resistant. The temperature experienced during the larval stage also had a significant effect on starvation resistance at adult stages, with those larvae raised at cold temperatures developing into adult phenotypes with reduced resistance to starvation. This study suggests that the effects of temperature on starvation resistance are highly complex and context dependent in *D. melanogaster*.

**Key words**: *Drosophila melanogaster*, Lipid storage, Starvation, Temperature

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Examining the impacts of macronutrients on life-history traits in *Drosophila melanogaster* using chemically defined diets

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Protein and carbohydrate are two major macronutrients that exert profound influences over fitness in many insects, including *Drosophila melanogaster*. Until recently, most studies examining the impacts of these macronutrients on various life-history traits in this species have used semi-synthetic diets that are not nutritionally well-defined. Here we used chemically defined diets to examine the patterns of larval and adult traits expressed across 34 diets systematically varying in the ratio and concentration of protein and carbohydrate. The shapes of the nutritional landscapes plotted for all larval and adult traits differed significantly from one another. Diverging nutritional optima identified for these landscapes suggest that *D. melanogaster* cannot maximize the expression of all life-history traits simultaneously, thus leading them to face a nutrient-dependent life-history trade-off.

**Key words**: Chemically defined diet, *Drosophila melanogaster*, Life-history trade-off, Nutritional geometry
The interactive effects of temperature and nutrition on lifespan and reproduction in
*Drosophila melanogaster*

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Diets influence lifespan and reproduction in insects, but little is known how temperature modulates the impacts of diet on these two key fitness components. Here we examined the interactive effects of temperature and nutrient balance on lifespan and egg production rate in *Drosophila melanogaster*. Newly emerged adult *D. melanogaster* were allowed to feed ad libitum on one of eight chemically defined diets differing in P:C ratio (1:16, 1:8, 1:4, 1:2, 1:1, 2:1, 4:1, or 8:1) under one of six ambient temperatures (13, 18, 23, 28, 31, or 33℃). For both males and females, lifespan was longest for *D. melanogaster* fed on P:C 1:16 diet at 13℃ and shortened as both temperature and P:C ratio increased. As indicated by a significant temperature-by-diet interaction for lifespan, the diet effects on lifespan were more pronounced at lower temperatures than at higher temperatures. Egg production rate was maximized on P:C 4:1 diet at 28℃.

**Key words:** *Drosophila melanogaster*, Egg laying, Lifespan, Nutrient balance, Temperature

Identification of G protein-coupled receptors in pheromone gland of *Maruca vitrata*

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G protein-coupled receptors (GPCRs) belong to cell membrane protein family, which regulate various physiological process such as reproduction, behavior and immune etc. In order to identify the GPCRs in pheromone gland of *Maruca vitrata*, we carried out transcriptome analysis from both females. Transcriptome analysis in the pheromone gland yielded approximately 22Gb and 47,528 transcripts showed positive FPKM value. 48 Genes involved in GPCRs were identified such as pheromone biosynthesis activating neuropeptide receptor (PBANr), prostaglandin receptors, neuropeptide receptor, 5-hydroxytryptamine receptor, galanin receptor, calcitonin gene-related peptide receptor, diuretic hormone receptor, gonadotropin-releasing hormone receptor, frizzled and orphan receptors, etc. Various expression of GPCRs in the pheromone gland indicates the role of pheromone gland may not be limited to the production of pheromone.

**Key words:** G protein-coupled receptor, pheromone gland, *Maruca vitrata*
Molecular and biochemical characterization of the bed bug salivary gland cholinesterase as an acetylcholine-sequestering enzyme

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The common bed bug, *Cimex lectularius*, possesses a cholinesterase expressed exclusively in the salivary gland (CISChE). In this paper, we investigated the molecular structure, tissue distribution patterns, and biochemical properties of CISChE and showed that CISChE exists as a soluble monomeric form or a soluble dimeric form connected by a disulfide bridge. Immunohistochemical analysis confirmed that CISChE was expressed in the epithelial cells of both the salivary gland and the duct. In addition, the secretion of monomeric CISChE through the proboscis during feeding was detected by western blotting using a CISChE-specific antibody. To predict the role of CISChE injected into the tissue of an animal host, we analyzed the extent of sequestration and hydrolysis of acetylcholine (ACh)/choline (Ch) by CISChE by ultra-performance liquid chromatography-tandem mass spectrometry. Kinetic analysis revealed that CISChE possesses extremely low Km (high affinity to ACh) and Vmax values. These findings suggest that CISChE functions as a sequestering enzyme specific to ACh (not to Ch) by having a very strong affinity to ACh but an extremely long turnover time.

**Key words**: Bed bug, *Cimex lectularius*, cholinesterase, salivary gland, sequestration, blood feeding
RNAi Applied to the Analysis of Gene Function in Multicolored Asian Ladybeetle, *Harmonia axyridis*

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*Harmonia axyridis* have become extremely popular through their extensive elytra and spot variation for many years. However, phenotypic polymorphism and striking visual phenotypes are not yet to be extensively studied. With growing attention to polymorphism of *H. axyridis*, it is imperative to study involved in genomic research in order to elucidate the molecular mechanisms underlying the diversity of elytra variation. To figure out suitable approach for analyzing genes of *H. axyridis*, we assessed RNAi as a tool for functional analysis. In order to demonstrate the utility of RNAi technique on *H. axyridis*, we conducted cDNA library screening to affirm silencing effect. We choose random genes from cDNA clones and the random genes were synthesized into dsRNA. After the injection of dsRNA into last instar larvae, we observed morphological defects or deaths. To investigate the effectiveness of knockdown in *H. axyridis*, we performed quantitative real time PCR on *H. axyridis* that appears the most distinctive features. These results provide that RNAi is highly applicable in *H. axyridis* and it will be useful for the gene functional analysis.

**Key words**: multicolored Asian ladybeetle, *Harmonia axyridis*, RNAi, gene screening, cDNA library

Development and performance of *Maruca vitrata* (Geyer) (Lepidoptera: Pyralidae) on different radiofrequency fields

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*Maruca vitrata* is one of the destructive pests of tropical legumes. Radiofrequency dependent development and adult performances of *M. vitrata* were examined at five radiofrequencies of 0 (control), 5, 10, 20, and 30 kHz on artificial diet. The results showed that radiofrequency have significant effects on the life variables of *M. vitrata*. Radiofrequency exposures on pod borer impacted on life-variables of *M. vitrata* and negative effects were also transmitted to the successive generations. The adults of *M. vitrata* were emerged with shorter longevity in case of radio-frequency treatment than untreated. Decreasing the radiofrequency level further reduced the longevity of adults. The shortest adult longevity was recorded for 5 kHz. Radiofrequency treatments have also affected on the adult performance such as weight of adult. The outcomes of this study are discussed in terms of an alternative to chemical treatments.

**Key words**: Soybean pod borer, frequency levels, adult performance, successive generation
**P071**

*In vivo* growth-inhibitory effect of Turmeric (*Curcuma longa* L.) extract against *Nosema ceranae*

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Nosema disease caused by the microsporidia *Nosema apis* and *Nosema ceranae* are a honey bee pathogen parasitizing. Nosema disease symptoms include digestive and absorption disorders because the spores damage epithelial tissue and potentially causing colony death. Recently, *N. ceranae* has been reported as an important threat to honey bee health. Turmeric (*Curcuma longa* L.) *Curcuma tonga* L. belongs to the family Zingiberaceae and is a perennial, tropical herb. Turmeric, the powdered rhizome, is used for medicinal purposes. The aim of this study was to evaluate the potential of Turmeric (*Curcuma longa* L.) for the control of *N. ceranae* in honeybees. For the study, we infected with *N. ceranae* spore through dosed and fed with the turmeric extraction at difference concentration. The data show that the turmeric extraction was not toxic for bee at least at 1% and the bees fed with 0.5% turmeric extraction had significantly lower infection rates. This data suggest that turmeric could be useful in alternative strategies for the control of *N. ceranae*.

**Key words :** Honey bee, *Apis mellifera*, Noseam disease, *Nosema ceranae*, Turmeric, *Curcuma longa* L.

**P072**

Feeding behavior of *Spodoptera litura* larva against the leaf treated with insecticides

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약제 처리에 따른 담배거세미나방(*Spodoptera litura*) 유충의 섭식 행동 및 반응을 조사하기 위해 1분 간격으로 잎면적을 자동 측정하였다. 담배거세미나방 유충의 섭식 행동은 섭식기와 비섭식기가 구분되었으며, 섭식기의 끝나면 비섭식기를 거쳐 탈피를 하고 다시 섭식기에 들어갔다. 1회 섭식 지속 시간은 약 15분으로 조사되었고, 영기 내 평균 섭식 회수는 약 27.5회로 섭식 지속 시간과 마찬가지로 영기에 따른 차이가 없었다. 약제 처리는 피망 잎을 Buprofezin methoxyfenozid과 BT (*Bacillus thuringiensis*) 500ppm 약액에 10초간 침지 처리하였다. Buprofezin methoxyfenozid을 처리 하였을 경우 섭식 시간은 평균 8-9분으로 감소하였고, 치사 전까지 섭식량은 각각 176mg으로 조사되었다. 하지만 BT제를 처리 시에는 담배거세미나방 유충은 치사하지 않았다.

검색어: 담배거세미나방, 잎면적 측정, 섭식 행동
**P073**

**Characterization of Entomopathogenic Fungi, *Lecanicillium attenuatum* Producing Secondary Metabolites with JHAN and Insecticidal Activity**

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The development of entomopathogenic fungi has received increasing interest as part of integrated pest management strategies as biocontrol agents. It is reasonable to assume that entomopathogenic fungi might produce secondary metabolites modulating juvenile hormone for their survival against defense mechanisms of host insects. In this study, acetone extracts of 189 entomopathogenic fungi cultured on unpolished rice medium were screened for their juvenile hormone antagonist (JHAN) activities using the yeast-two hybrid system. Among 14 extracts showing JHAN activities, extract of the F-145 showed high level of insecticidal activities against both *Plutella xylostella* and *Aedes albopictus*. This isolate was identified as *Lecanicillium attenuatum*. These results suggested that the *Lecanicillium attenuatum* could be useful for development of eco-friendly insecticides.

**Key words**: Entomopathogenic fungi, Secondary metabolite, IGR, *Lecanicillium attenuatum*

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**P074**

**Purification and characterization of insecticidal compounds from *Streptomyces* sp.**

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Beet armyworm, *Spodoptera exigua*, is known to be hard-to-kill pest by having high resistance to insecticides and its control is intensely dependent on fewer insecticides. In this study, the ethyl acetate extract of *Streptomyces* sp. was evaluated to find novel insecticidal agents against *S. exigua*. In order to determine the identity of insecticidal compounds, the crude ethyl acetate extract was fractionated based on the TLC profiling and bioassay-guided monitoring. These results indicated that the non-polar fraction have high level of insecticidal activity against second instars of *S. exigua*. These findings suggested that secondary metabolites produced by *Streptomyces* sp. could be considerable potential resources as novel insecticidal formulation candidates.

**Key words**: *Streptomyces*, secondary metabolites, insecticidal activity, *Spodoptera exigua*
Insecticidal activity of *Streptomyces* sp. with Juvenile hormone antagonist activity against *Plutella xylostella*

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Streptomyces has been reported to produce various secondary metabolites which have the potential to become environmentally safe insecticides. In this study, 1,274 streptomyces culture filtrates were screened for their JHAN activity in order to identify novel insecticidal compounds. 34 isolates with high levels of JHAN activity were selected, and their insecticidal activities were tested against *Plutella xylostella* larvae. Among them, IMBL-263 which was revealed to be *Streptomyces anulatus* by 16s rRNA sequencing showed the highest insecticidal activity. Also, systemic activities of secondary metabolites extracted from the *S. anulatus* on plant, *Brassica napus*, were investigated. These results suggested that secondary metabolites from the *S. anulatus* might be useful for development of novel environmentally benign insecticides.

**Key words**: streptomyces, secondary metabolites, insecticidal activity, Juvenile hormone antagonist

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The metabolites differences between long-winged (L) and short-winged (S) Small brown planthopper revealed by metabolomic analysis

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One of the leading pests of rice, small brown planthopper (*Laodelphax striatellus*) can grow up to have either short or long wings, depending on conditions. However, under the same breeding conditions, the phenotypes of the long- and short-winged small brown planthopper observed to keep the first collected phenotype. To investigate the mechanism involved in wing dimorphism, metabolomic researches have been conducted. In this study, we observed several metabolites change, and the difference of metabolites could provide clues to the relationship between physiological changes in the small brown planthopper and ecological transport.

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**Key words**: small brown grasshopper, wing dimorphism, metabolites, metabolomics
P077

Preliminary test for LED wavelength selection for *Orius laevigatus* (Hemiptera: Anthocoridae) using Y-tube

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Artificial light is frequently used for plant growth and pest attraction traps in greenhouses. In addition, natural enemies may utilize this artificial light for colonization in greenhouses. *Orius laevigatus* is a biological control agent of whiteflies and thrips. The Y-tube selection test was conducted against *O. laevigatus* for 11 wavelengths (365, 385, 395, 405, 410-420, 420-430, 440-450, 490-500, 520-530, 590-595 and 620-630 nm) of LED and white light (5000k) for a control. One pipe of the Y-tube was allocated for insect entrance and other two pipes of the Y-tube were installed transparent sticky trap along with white LED and test wavelength, respectively. At least, three replications were conducted for each wavelength and 40 to 60 individuals of *O. laevigatus* were used for each replication. Attraction rate of 365 to 405 nm wavelength was above 50 % and highest at 385 nm (83.7 %). Attraction rate of 490 to 630 nm was below 20 % and lowest at 620-630 nm (1.4 %). The results indicate that *O. laevigatus* attracted most to 385 nm wavelength and this light may be useful for using *O. laevigatus* in green houses. Further research is needed using selected LED wavelength.

Key words: LED, Y-tube, attraction, *Orius laevigatus*, photoresponse

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P078

Honeybee (*Apis cerana*) Vitellogenin Acts as an Antimicrobial and Antioxidant Agent in the Body and Venom

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Honeybee (*Apis mellifera*) egg-yolk protein vitellogenin (Vg) plays roles in immunity, antioxidation, and life span beyond reproduction, but it also acts as an allergen Api m 12 in venom. Here we established antimicrobial and antioxidant roles of honeybee Vg in the body and venom. Using the cDNA encoding Vg identified from Asiatic honeybee (*A. cerana*) workers, recombinant *A. cerana* Vg (AcVg) protein of approximately 180 kDa was produced in baculovirus-infected insect cells. In *A. cerana* worker bees, AcVg was expressed in the fat body and venom gland and was present in the secreted venom. AcVg induced structural damage in microbial cell walls via binding to microbial surfaces and exhibited antimicrobial activity against bacteria and fungi. AcVg protected mammalian and insect cells against oxidative damage through direct shielding of cell membranes. Interestingly, AcVg exhibited DNA protection activity against reactive oxygen species (ROS). Furthermore, the transcript level of AcVg was upregulated in the fat body, but not in the venom gland, of worker bees with antimicrobial peptides and antioxidant enzymes in response to microbial infection and oxidative stress. Our data indicate that AcVg is involved in innate immunity upon infection and in a defense system against ROS, supporting a crucial role of honeybee Vg as an antimicrobial and antioxidant agent in the body and venom.

Key words: *Apis cerana*, Honeybee, Vitellogenin, Antimicrobial activity, Innate immunity, Antioxidant activity, Reactive oxygen species
Honeybee (Apis cerana) Major Royal Jelly Protein 2 Exhibits Antimicrobial and Antioxidant Activities

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Major royal jelly proteins (MRJPs), important protein components of bee royal jelly (RJ) and exclusive nourishments for queen, exhibit various biological and pharmacological activities. RJ is one of the most studied bee products, but the crucial roles for MRJP2 as an antimicrobial and antioxidant agents remain largely unknown. Here we demonstrated the antimicrobial and antioxidant functions of the Asiatic honeybee (Apis cerana) MRJP2 (AcMRJP2). Recombinant AcMRJP2 of approximately 53 kDa was expressed in baculovirus-infected insect cells, and it exhibited antimicrobial activity against bacteria, fungi, and yeast via binding to microbial surfaces and inducing structural damage in microbial cell walls. AcMRJP2 protected mammalian and insect cells against oxidative damage through shielding of cell membranes. Interestingly, AcMRJP2 exhibited DNA protection activity and DPPH radical-scavenging activity. Altogether, our data demonstrated that AcMRJP2 functions as antimicrobial and antioxidant agents.

Key words: Apis cerana, Honeybee, Royal jelly, Major royal jelly protein 2, Antimicrobial activity, Antioxidant activity

Relationship between feeding damage by herbivorous insects and environmental factor in island

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우리나라는 약 4,000여개의 크고 작은 섬들로 이루어져 있고, 그 속에는 다양한 생물종들이 주변 환경과 상호작용하며 서식하고 있다. 그 중 초식성 곤충은 생물 구성의 1/4로 많은 비율을 차지하며, 생산자인 식물을 먹고 2차 소비자의 먹이원이 됨으로써 생태계의 중간 고리를 맡는다. 본 연구는 다도해해상국립공원에 속해 있는 크기가 다른 6개의 섬에서 초식성 곤충의 영향을 알 수 있는 식흔과 여기에 영향을 줄 수 있는 환경요인(섬 면적, 육지와의 거리, 해안선 길이, 최고고도)과의 관계를 알아보았다. 식흔을 알아보기 위해 낙엽활엽수인 4개의 수종(참나무속, 벚나무속, 예덕나무속, 오리나무속)을 선정하여 2017년 6월과 9월에 관찰하였다. 이와 함께 초식성 곤충 종 수와 종 다양성이 풍부한 나방을 채집하여 식흔자료와 비교하였다. 조사결과 섭 면적이 커질수록, 해안선 길이가 길수록, 최고고도가 높을수록 식흔량이 증가하는 경향을 보였고, 나방 종수도 증가하였다. 반면 육지와의 거리가 멀수록 식흔량이 감소하는 경향을 보였고, 나방 종수도 감소하였다. 이러한 결과를 통해 초식성 곤충의 다양성과 환경요인이 관련 있는 것을 확인할 수 있었다.

검색어: 초식성 곤충, 식흔, 다도해해상국립공원, 섬생물지리학, 낙엽활엽수
P081
Comparison of the community structure and changes of ground beetle (Coleoptera: Carabidae) as indicator species in forest genetic resource reserve

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2016년도에 조사를 수행한 경상북도 내 위치한 산림유전자원보호구역 3개 지역(봉화·영주·울진)의 곤충 군집 변화를 확인하기 위하여 5월에서 9월까지 함정 트랩(pitfall trap)을 이용하여 5회씩 3반복하여 각각 상대적으로 비교 하였다. 채집된 박정벌레류는 박정벌레과 등 22과 141종 2,415개체가 확인 되었으며, MRPP (Multi-response Permutation procedures)분석 결과 서식지간의 군집구조차이가 있음을 확인 하였고(p < 0.001), Bray-cuts 분석결과 군집간의 차이와 함께 신갈나무 군락이 보행성 박정벌레류의 종 풍부도에 큰 영향을 주는 것으로 나타났고 소나무군락은 비교적 낮은 영향을 받았다. 식생유형에 대한 지표 종 분석결과 신갈나무 군락에서 붉은칠납작먼지벌레(Synuchus cycloderus Bates, 1873)를 포함한 4종, 자작나무 군락에서는 노랑털검정반날개(Ocypus weisei Harold, 1877)를 포함한 3종, 소나무 군락에서는 홍딱지반날개(Platydracus brevicornis Motschulsky, 1862)를 포함한 3종의 지표종 변화를 확인 하였다.

검색어: 지표성 박정벌레, 산림유전자원보호구역, 함정 트랩, 군집분석, 지표종

P082
Herbivorous insect feeding activity on oak tree and hornbeam tree in temperate forest

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참나무와 서어나무는 온대지역에 걸쳐 널리 분포하고 있으며, 다양한 초식곤충의 먹이원이 되는 것으로 알려져 있다. 이 연구에서는 지리산국립공원 온대림에서 참나무림(반선)과 서어나무림(상선암)에서 초식곤충 활동량을 알고자 하였다. 각 조사지역에 0.1ha의 방형구를 설치하여 참나무와 서어나무의 분포를 확인 한 뒤 개체별로 초식곤충의 활동량인 잎 손상 지수를 측정하였다. 일 손상 지수는 손상 퍼센트로 환산하여 분석하였다. 측정결과 전체 4,413장의 잎을 관찰하였으며, 참나무림에서는 2,683장, 서어나무림에서는 1,730장의 잎이 조사되었다. 초식곤충의 활동량은 참나무림과 서어나무림에서 각각 차이를 보였으며 서어나무림인 상선암에서 참나무의 식흔량과 서어나무의 식흔량이 참나무림인 반선보다 모두 높게 나타났다. 이 연구결과를 바탕으로 온대림 우점 수종인 참나무와 서어나무에서 초식곤충의 활동량을 정량적으로 추정할 수 있을 것으로 생각된다.

검색어: 초식곤충 활동량, 식흔, 잎손상, 참나무, 서어나무, 온대림
Analyzing climate suitability and influences of other environmental factors on occurrence of Korean Oak Wilt (KOW)

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Korean Oak Wilt (KOW), was first recorded in Gyeonggi Province in 2004, and since then has increased steadily in its occurrence and ecological and economic impacts. *Platypus koryoensis* vectors the symbiotic fungus *Raffaelea quercus-mongolicae*, which is the causative agent of KOW. KOW may be closely related to recent climate changes, which have allowed *P. koryoensis* to extend its distribution range in Korea. And it results in greater overlap with the susceptible host tree, *Quercus mongolica* throughout Korea. In this regard, changes in the climate suitability of *P. koryoensis* and *Q. mongolica* were predicted using CLIMEX model and the influences of other environmental factors such as elevation and the number of days with heat wave were also identified in this study.

**Key words**: Korean Oak Wilt, *Platypus koryoensis*, CLIMEX model, environmental factors

Comparison of Insect Communities in Gonggeom-ji Wetlands Protection Area in Relation to Collecting Methods

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본 조사는 채집방법에 따른 곤충군집을 비교하기 위해 공검지 습지보호지역 내에서 쓸어잡기, 함정트랩, 버킷트랩 세 가지 방법을 이용하였다. 조사 시기는 5월 15~16일, 8월 3~4일, 11월 6~7일 총 3회 실시하였으며, 조사는 보호지역 중심부에서 실시하였다. 본 연구결과 세 방법으로 총 7목 51과 110속 120종 14,717개체가 채집되었다. 채집방법별로 쓸어잡기에서 4목 25과 36속 37종 331개체, 함정트랩에서 3목 12과 18속 19종 30개체, 버킷트랩에서 6목, 38과 76속, 84종, 14,121개체가 조사되었다. 군집 분석결과 다양도 지수는 쓸어잡기가 3.63으로 가장 높게 나타났으며 유사도 지수는 버킷트랩이 0.2이하로 매우 낮았다.

**검색어**: 공검지 습지보호지역, 채집방법, 쓸어잡기, 함정트랩, 버킷트랩, 군집 분석
Insect Pollinators use in *Cypripedium japonicum* Thunb.

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덕유산국립공원 내 멸종위기 야생생물 1급 광릉요강꽃 (*Cypripedium japonicum* Thunb.)의 자생지 보전과 복원기초자료 축적을 위해 개화기에 찾아오는 곤충을 조사하였다. 그 결과, 5개목 19과 26종의 곤충이 관찰되었지만 꽃 내부로 출입하는 곤충은 별도 뿐이었다. 광릉요강꽃 구조상 화분 매개를 위해서는 우수리뒤영벌 (*Bombus ussurensis*)과 호박벌 (*Bombus ignitus*)과 같은 몸체의 두께가 1cm 내외의 꿀벌과가 효과적이다. 그만큼 꿀벌과 곤충은 꽃이 첫 무렵(5월 18일 이후)부터 관찰되었으며, 꽃 내부로 출입하는 비율은 14.3%로 다른 과(Family)에 비해 낮게 나타났다. 광릉요강꽃의 자연수정률이 낮은 원인으로 화분매개곤충의 활동시기와 개화시기가 일치하지 않는 점으로 여겨지는 바, 개화시기와 화분매개곤충의 유효적산온도와의 상관관계를 연구할 필요가 있다. 다불어 새순이 난 때 진딧물류, 수정된 씨방에서 굴파리 (*Ophiomyia* sp.)가 발견되어 결실율을 높이기 위해서는 이들의 기주식물을 조사해 자생지에서 격리 및 타 기주 내 방제방법 연구가 필요하다.

검색어: 광릉요강꽃, 화분매개곤충, 가해곤충, 우수리뒤영벌, 호박벌, 굴파리

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**P086**

The status of alien insect species in the southern region of Korean peninsula

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국립생태원에서는 2016-17년에 걸쳐 한반도 남부지역에 해당되는 충청권, 경상 지역에서 외래생물 전국 서식실태조사를 수행하였으며, 그 중 외래곤충 현황에 대한 결과이다. 2016년 충청권 랜권역 65개 시·군에서 총 8목 20과 28종의 외래곤충이 조사되었으며, 그 중 2종의 미기록종 (*Hindoloides bipunctatus*, *Salurnis marginella*)이 확인되었다. 해당 권역에 분포하는 외래곤충 중 갈색날개매미충은 48개 시·군으로 가장 많은 지역에서 서식이 확인되었고, 다음으로 꽃매미(41), 등검은말벌(35), 바금나무방패벌레, 해바라기방패벌레(30), 미국선녀벌레(27) 순이었다. 2017년 경상권 43개 시·군에서 총 6목 24과 32종의 외래곤충이 조사되었으며, 그 중 1종의 미기록종 (*Dentatissus damnosus*)과 2종의 미접종(목식부전나비, 무리박이체비나비)이 확인되었다. 해당 권역에 분포하는 외래곤충 중 남방노랑나비가 37개 시·군으로 가장 많은 지역에서 서식이 확인되었고, 다음으로 꽃매미(36), 해바라기방패벌레(35), 등검은말벌(31), 대저품잎벌레(30) 순이었다. 남부지역 총 133개 시·군에서 꽃매미가 가장 많은 지역(77)에서 서식이 확인되었으며, 다음으로 갈색날개매미충(70), 등검은말벌(66), 해바라기방패벌레(65) 순이었다.

검색어: 남부지역, 외래곤충, 미기록, 미접
P087

Over-Wintering Stage of Citrus Leaf Miner (*Phyllocnistis citrella* Stainton) in Citrus Orchards in Jeju Area

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The citrus leaf miner (CLM) is a of important citrus pests in Jeju island, but it’s not clear about ecology of over-wintering in Jeju. We investigated the developmental stage to know how the CLM overwinters in 20 sites. And we investigated the mortality of larvae, pupae and adult stage of CLM in open citrus cultivated field December, 2017 to April 2018 and growth chamber conditions(from –10 to 5 °C). As a result, no larvae and adult survived open field during winter. We concluded that the CLM usually overwinters as pupa during winter.

Key words: *Phyllocnistis citrella*, over-wintering, low temperture, winter mortality, overwintering stage

P088

Parameter Estimation for a Temperature-dependent Development Model of Citrus Leaf Miner (*Phyllocnistis citrella* Stainton) on Satsuma Mandarin

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The citrus leaf miner (CLM) is an important citrus pest. A thorough understanding of the biology and population dynamics of CLM are essential for development of reliable pest population prediction system. We investigated the developmental periods of the species under ten constant temperature schemes (12.5°C~39°C). Furthermore, we established a development model of CLM, based on the result of a laboratory experiment. The immature developmental duration of CLM at constant temperatures were 63.5 days at 15°C, 23.9 days at 21°C, 15.6 days at 27°C, and 12.3 days at 33°C, showing statistically significant difference among temperature regimes. The lower threshold temperature and thermal constant were 11.3°C and 243.7 DD, respectively, for immature development. In relation to temperature, non-linear development models were established for each developmental stage of CLM.

Key words: *Phyllocnistis citrella*, temperature-dependent development, development model, citrus pest
Development of *Maruca vitrata* (Geyer) (Lepidoptera: Pyralidae) on leguminous crop

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*Maruca vitrata* is an important insect pest of soybean. This study was conducted to investigate the occurrence and development of *Maruca vitrata* on soybean and other leguminous crops. The results showed that *Maruca vitrata* could develop on soybean, mung bean, and lentil, but not on cowpea. The development rate was highest when artificial diet was provided, followed by soybean and lentil. The generation time was shortest when artificial diet was provided, followed by soybean and lentil. The key words for this study are: *Maruca vitrata*, soybean, development, and growth.

The occurrence status of apple leafminer, *Phyllonorycter ringoniella* (Matsumura) on apple orchards in Gyeongbuk

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*Phyllonorycter ringoniella* is known to be an important insect pest of apple. This study was conducted from 1992 to 2017 in the major apple producing districts in Gyeongbuk area, and examined the occurrence and damaged leaf (%) of leafminer at monthly interval in “Fuji” apple orchards. The damaged leaf was the highest in 1992 (5%), the gradually decreased until 2004, and then increased again until 2008, after which it decreased. The damaged leaf was not significant between rootstocks including seedling rootstock, M.9, and M.26. The key words for this study are: apple, leafminer, damaged leaf, and rootstock.
Molecular Epidemiology for the Tracing Origin of Oriental Fruit Flies
(*Bactrocera dorsalis* sp. complex)

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The oriental fruit fly, *Bactrocera dorsalis* (Hendel), has potential of serious damage to various vegetables or fruits, especially genus of *Citrus*, such as mandarin orange and tangerine in Korea, where its larvae do damages. Animal and Plant Quarantine Agency of Korea and Animsl Systematics Laboratory of Kunsans National University have collected the samples of oriental fruit fly in East Asian countries, Vietnam, Philippines, Myanmar, China, Cambodia, India Nepal and Laos. To confirm genetic differences and structure of *B. dorsalis* population samples collected from those countries, we analyzed 192 individuals from 28 locations over 7 countries using 15 microsatellite loci. In total samples, number of different alleles, number of effective alleles and Shannon's Information Index were 6.421±0.364 (standard error, SE), 3.664±0.137 (SE) and 0.902±0.030 (SE), respectively. Grand means (±SE) of observed and expected heterozygosity over all loci and populations were 0.534 (±0.018) and 0.597 (±0.017), respectively. Among all populations, *F*st values ranged from 0.016 to 0.705 with averaging 0.194 (±0.026).

**Key words:** *Bactrocera dorsalis* sp. complex, microsatellite, Oriental fruit fly, population genetics

Forecasting Rice leaf roller and Oriental armyworm in Korea using Maximum Entropy Model

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비래해충인 혹명나방(*Cnaphalocrocis medinalis*)과 멸강나방(*Mythimna separata*)은 아시아의 주요 벼 재배국가에 평범하게 분포하고 있는 벼의 주요 해충이다. 국내에서는 비벌구, 환동벌구와 함께 중국에서 비래하여 나타나는 것으로 알려져 있다. 혹명나방과 멸강나방의 발생지역과 통계적으로 유의미한 상관관계에 있는 환경변수를 확인하고, 국내에서의 지속적인 발생 가능성을 알아보기 위해 Maxent (Maximum Entropy Model) 3.3.2를 사용하였다.

검색어: 비래해충, 혹명나방, 멸강나방, Maxent 모형
Spatial pattern analysis for migratory insect pests distribution in Jeolla-province

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Five major migratory insect pest populations (Nilaparvata lugens, Sogatella furcifera, Laodelphax striatellus, Cnaphalocrocis medinalis, Mythimna separata) migrate from the southern China to Korea through jet streams. This study was conducted from July 2017 to August 2017 in rice paddy of Jeolla-province. C. medinalis and M. separata collected using pheromone traps, while N. lugens, S. furcifera and L. striatellus collected using 3 methods (visual surveys, sweeping surveys, sticky traps). Spatial Analysis by Distance IndicEs (SADIE) was used to analyze spatial distribution and index of aggregation $I_a$, index of clustering $V_i$, $V_j$ were used to investigate the spatial distribution. Also, the clustering indices were mapped as red-blue plot.

Key words: migratory insect pests, Jeolla-province, spatial pattern, SADIE

Using MaxEnt for predicting the invasion possibility of Leptoglossus gonagra (Hemiptera: Coreidae) in Korea

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허리노린재과(Coreidae)에 속하는 Leptoglossus gonagra (가칭: 기장허리노린재)는 북미 원산으로 현재 아프리카, 오스트레일리아, 동남아시아 등 폭넓게 분포하고 있으며 다양한 채소와 과일을 가해하는 광식성 곤충으로 알려져 있다. 우리나라의 2016년 부산시 기장면의 호박 재배지에서 약충과 성충이 확인되었으나, 이듬해에는 현장조사에서 서식이 확인되지 않았다. 본 연구는 MaxEnt 모형과 세계적 위치 정보를 이용하여 L. gonagra의 서식 및 생존과 영향을 주는 환경요인 및 국내 서식 가능성을 확인하고자 하였다. 위치자료는 GBIF (Global Biodiversity Information Facility), DISCOVER LIFE 웹사이트에서 제공하고 있는 총 99지점을 이용하였고 환경변수로는 WorldClim의 생물기후(bio)를 19개를 활용하였다. 예측 모델은 평균 AUC 값 0.928으로 높은 신뢰도를 보였으며, 등온성(bio3)과 가장 따뜻한 분기의 강수량(bio18), 기온의 계절성(bio4), 가장 습한 분기의 강수량(bio16) 순으로 기여도가 높았다. 고온다습한 열대성 기후 지역에서 출현 가능성이 높게 나타났고, 우리나라에서는 매우 낮은 것으로 분석되었다.

검색어: 종분포모형, 침입외래곤충, 출현가능성
P095

Comparison of climatic similarity for evaluating possibility of *Leptoglossus occidentalis* inhabitation in South Korea

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Climatic factors are known to be the most critical on estimating potential distribution of species, suggesting that an area having similar climate to origin of a pest may be vulnerable to its invasion. In this study, we selected *Leptoglossus occidentalis*, a pest causing significant forest damage in South Korea, and compared current climate of its 3 known origins with that of 74 cities in South Korea by using ‘Match Climate’ function in CLIMEX software. Result showed that overall climatic similarity between them was moderately high, indicating consistency of climatic similarity with the current distribution of *Leptoglossus occidentalis* in South Korea.

Key words : Climatic similarity, Match Climates, CLIMEX, *Leptoglossus occidentalis*

P096

Assessment of climate suitability for *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae) in Asia by using CLIMEX

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*Phthorimaea operculella* is a pest causing serious damages in worldwide potato cultivation. As climatic factors are considered to be the most crucial on species’ distribution, we tried to compare climatic conditions between a native area of *Phthorimaea operculella* with cities in South Korea and other areas in Asia based on climatic similarity provided by 'Match Climates' function of CLIMEX software. Even though there is arguing regarding origin of *Phthorimaea operculella*, we selected Peru and Bolivia as home climate, and compared its climatic similarity to other areas in Asia with application of SRES A1B 2030 climate change scenario. Result showed that South Korea has favorable climatic condition for *Phthorimaea operculella*. Also, most of Asia except north China and south Russia showed the similar climate suitable for *Phthorimaea operculella*.

Key words : match climates, CLIMEX, *Phthorimaea operculella*, climate change scenario
Genetic relationships between *Bemisia tabaci* MED (Hemiptera: Aleyrodidae) populations in tomato nurseries and commercial greenhouses

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The *Bemisia tabaci* (Hemiptera: Aleyrodidae) is a pest that sucks a plant's phloem, excretes nectar and infects tomatoes with TYLCV (*Tomato Yellow Leaf Curl Virus*), causing severe economic damage. In order to explore the cause for occurrence of areas where the genetic structure of *B. tabaci* MED (Mediterranean) was reversed in a short period of time, this study was conducted. We collected and analyzed the *B. tabaci* MED populations from tomato greenhouses in some areas where their genetic structure was reversed between two years 2016 and 2017. As a result, the genetic structure of *B. tabaci* MED populations was found to be close between populations of the nursery and the greenhouses where tomato seedlings were supplied from that nursery, even if greenhouses were located far away each other. Further study is needed to identify the causes for occurrence of abrupt reverse of genetic structures of *B. tabaci* MED populations observed in some areas throughout the country.

**Key words:** *Bemisia tabaci* MED, Whitefly, Population genetics, Nursery

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Temperature-dependent Development Models and Life Tables of The Foxglove Aphid, *Aulacorthum solani*, on Soybean

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Development and fecundity of the foxglove aphid, *Aulacorthum solani* (Hemiptera: Aphididae) were investigated at ten constant temperatures (photoperiod: 15L:9D) from 2.5 to 30°C on soybean (*Glycine max*) leaves. The nymphs couldn’t emerge to adults at 2.5 and 30°C. The lower development temperature threshold and thermal constant of development completion estimated with a linear development model in nymph were 5.02°C and 131.2 degree-days. The lethal temperatures were estimated as 33.9 and 32.5°C with Lactin 2 and Logan 6 non-linear models, respectively. Mean generation time (from 78.4 to 11.8 d) decreased with increasing temperatures (from 7.5 to 27.5°C). The highest net reproductive rate (77.4) was observed at 20°C. The highest intrinsic rates of population increase (0.282) and shortest population doubling times (2.07 d) were recorded at 25°C.

**Key words:** *Aulacorthum solani*, *Glycine max*, temperature-dependent development model, life table
**Study of occurrence and distribution on *Atherigona orientalis* in Korea during 2017**

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The fruit house fly *Atherigona orientalis* (Schiner), which is belonging to Muscidae, Diptera, is classified as quarantine pest and first reported in Korea at 2016. Annual occurrence and spatial distribution pattern of *A. orientalis* was biweekly monitored from April to December, using fly-wine trap in Korea. *A. orientalis* was first found in Gwangyang in June and increased populations by September, 2017. It is considering that *A. orientalis* is difficult to survive during winter season because this species is belonging to non-diapausing insect, so it may possible to be overwintering in warm place such as green house of paprika and tomato during winter. Based on this survey, *A. orientalis* is considered to be excluded from quarantine pests.

**Key words**: Fruit house fly, *Atherigona orientalis*, Quarantine, Overwintering, Distribution, Occurrence

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**Temperature dependent development model of *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) and its validation in Taiwan**

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The oriental fruit fly is a major polyphagous insect pest with a worldwide distribution. The effects of temperature on stage-specific development were investigated at eight constant temperatures (13.0, 14.4, 16.2, 19.5, 23.8, 27.7, 31.8 and 34.8°C). Stage-specific lower developmental thresholds and thermal constants were determined using linear regression. The lower and higher temperature threshold (TL and TH) were estimated using the Sharpe-Schoolfield-Ikemoto (SSI) model. The daily adult emergence frequency of *B. dorsalis* was estimated in relation to adult age and temperature. Thermal performance was compared among *B. dorsalis* populations from different locations in Taiwan.

**Key words**: *Bactrocera dorsalis*, development completion frequency, temperature, nonlinear function, voltinism
**P101**

**Effects of temperature on fecundity, longevity and life table parameters of *Riptortus pedestris* (Fabricius) (Hemiptera: Alydidae)**

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*Riptortus pedestris* is one of economically important insect pests in soybean fields. The study was conducted at six constant temperatures of 15.8, 19.7, 24.0, 27.8, 32.6 and 35.5°C. We investigated the biological traits of *R. pedestris* adults. *R. pedestris* adults survived at all temperatures tested but female did not oviposit under 15.8°C. The longevity of *R. pedestris* male was longer than that of female. Oviposition model was constructed using nonlinear functions and the number of eggs produced by a cohort of females was estimated in relation to constant temperature and adult age. The life table parameters in relation to temperature were analyzed.

**Key words**: *Riptortus pedestris*, fecundity, longevity, oviposition model, life table analysis

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**P102**

**Comparison the annual phenology pattern and spring emergence of *Riptortus pedestris* (Fabricius) (Hemiptera: Alydidae) in Korea**

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*Riptortus pedestris* is a polyphagous species and an economically important insect pest of soybean. We investigated the phenology of *R. pedestris* at 13 locations - Jeonju, Naju, Goheung, Milyang, Gunwi, Andong and 7 locations of Jeju. Fish trap was used for monitoring *R. pedestris*. The traps were baited with lures containing a 1:5:1 ratio of myristyl isobutyrate, (E)-2-hexenyl (E)-2 hexenoate and (E)-2-hexenyl (Z)-3-hexenoate. There was difference the first adult catch and local temperatures among sampling sites. To determine spring emergence distribution and annual phenology pattern, we used the monitoring data and ambient temperature from each sampling sites. We compare the seasonal occurrence and spring emergence between 2016 and 2017 in each location.

**Key words**: *Riptortus pedestris*, phenology, pheromone trap, spring emergence, temperature
A hypothesis related to long distance dispersal (LDD) of KOW (Korean Oak Wilt) reflecting behavior of *Platypus koryoensis*

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Korean oak wilt (KOW) caused by *Raffaelea quercus-mongolicae* and its vector, *Platypus koryoensis* is one of the most severe forest pests in Korea. In spite of its importance, information about dispersal of *P. koryoensis* is very limited. In here, a hypothesis related to long distance dispersal (LDD) of KOW reflecting behavior of *P. koryoensis* is proposed. When attack density of *P. koryoensis* increased, location of entry holes in the trunk moved to upward. The individuals which escaped from entry holes in upper trunk had potential to fly upper part of trees and they flew longer distance probably by aid of winds. We suggested that this density dependent dispersal of the beetle explain the spatial dynamics of KOW in large scale.

**Key words**: Korean oak wilt (KOW), Long distance dispersal (LDD), *Platypus koryoensis*, *Raffaelea quercus-mongolicae*, Spatial dynamics

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Fumigant susceptibility to Cigarette beetle (*Lasioderma serricorne*, Fabricius)

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The susceptibility of the Cigarette beetle, which are pests in tobacco, to methyl bromide and phosphine fumigants was evaluated. Five concentrations of each methyl bromide were selected for all stages and treated for 4 hours. As a result, 100% larvae were observed in eggs CT 51.20, late larva CT 73.61, pupa CT 71.87 and adult 52.87 mg h / L, respectively. The LCT50 values for methyl bromide were 13.896 for eggs, 36.038 for late larvae, 25.172 and 21.758 mg / l, respectively.

The phosphine treatment was carried out for 5 to 6 concentrations (0.025, 0.051, 0.099, 0.501, 0.999 and 1.500 mg / L) for 20 hours. As a result, egg and late larvae showed 100% larvae at CT 5.137 and 6.435 mg h / L, respectively, and 61.9% and 98.9% of larvae and adult larvae were similar to each other. Pupae showed 86.4% larvae at CT 10.520 and 100% larvae at over 13.777 mg / h of CT. The LCT50 values for phosphine were 0.317 for eggs, 0.649 for late larvae, 3.748 for pupa and 0.703 mg / l for adults.

**Key words**: Methyl bromide, Phosphine, Cigarette beetle, Sensibility
Susceptibility of Two Species of Agricultural Pest Using Carbonyl sulfide

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Carbonyl sulfide is a chemical that is registered as a crop protection product in Australia due to microorganisms such as soil, plant roots, branches, fertilizers and compost. In order to develop new fumigants for domestic use, the susceptibility of Carbonyl sulfide fumigants to two agricultural pests was evaluated. The susceptibility of peach aphid and spotted mite, which is an agricultural pest, was evaluated. After 5 hours of treatment (10, 20, 40, 60, and 80 mg / L). As a result, peach aphid larvae showed a high mortality rate of 97.6% at 10 mg / L and 100% at 20 mg / L or more. Larvae were found to have a rate of 95.8% at 80 mg / L. The insect mortality rate was 91.8% at 60 mg / L and 94.1% at 80 mg / L.

Key words: Carbonyl sulfide, peach aphid, spotted mite, susceptibility

Efficacy and phytotoxicity assessment of low-temperature treatment on citrus to control Mediterranean fruit fly, Ceratitis capitata

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Mediterranean fruit fly, Ceratitis capitata, is one of the most important quarantine pest worldwide. Fruit flies cause serious damage on orchard, and also can cause quarantine problem to fruit exportation. Recently, because of global warming, there is threats of fruit fly invasion to Korea, especially to Jeju island. So there should be a anticipative research about fruit fly control.

Many physical quarantine treatment methods, like heat treatment and low-temperature treatment, are developed to control quarantine pests. Recent researches indicate that low-temperature treatment shows good efficacy on several quarantine pests without phytotoxicity. In this trial, we’ve applied the low-temperature treatment on citrus at laboratory and pilot scale containers to validate efficacy and phytotoxicity.

Egg and larvae stage of C. capitata was completely controlled after 5 days and 8 days low-temperature treatment at 0°C respectively, and there was no phytotoxicity on citrus. These results indicate that the low-temperature treatment can be applied to control fruit fly on citrus fruit.

Key words: Mediterranean fruit fly, Low-temperature treatment, efficacy, phytotoxicity
**P107**

Parasitism patterns of the parasitic wasps on *Monochamus saltuarius* (Coleoptera: Cerambycidae) in *Pinus koraiensis* forests

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*M. saltuarius* Gebler (Coleoptera: Cerambycidae) is a well-known as vector species of the pine wood nematode (PWN) in the northern areas of South Korea. In 2017, larval parasitoids of *M. saltuarius* and their parasitism patterns were investigated in *Pinus koraiensis* forests with consideration of sentinel logs positions (height: 0 m vs. 1.8 m), distances from the edge to the center of the forest (0, 20, 40, 60, 80m), and damage degrees of the pine wilt disease (infested area, buffer area, and uninfested area). In total six of larval parasitoids were collected: *Spathius verustus*, *Sclerodermus harmandi*, *Cynopterus flavator*, *Heydenia testacea*, *Heydenia* sp., *Braconidae* sp. The parasitism rate to larvae of *M. saltuarius* larvae was not affected by sentinel log positions. However, the parasitism rate was significantly higher in infested areas compared to the buffer and uninfested areas. In the infested area, the parasitism rate was increased with distance from forest edges.

**Key words**: Japanese pine sawyer, parasitoid wasp, pine wood nematode, sentinel log, parasitic pattern

**P108**

Insecticidal activity of Lamiaceae plant essential oils and their constituents against *Blattella germanica* L. adult

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The insecticidal activities of 13 Lamiaceae plant oils and their components against adult German cockroaches, *Blattella germanica* L. (Blattodea: Blattellidae), were evaluated using fumigant and contact bioassay. Among the tested oils, basil, pennyroyal, and spearmint showed the strongest insecticidal activities against adult *B. germanica*. Insecticidal activity of pennyroyal was 100% against male *B. germanica* at 1.25 mg concentration in fumigant bioassay. Basil and spearmint revealed 100% and 100% insecticidal activity against male *B. germanica* at 5 mg concentration, but their activities reduced to 80% and 25% at 2.5 mg concentration, respectively. In contact toxicity bioassy, basil, pennyroyal, and spearmint oils exhibited 100%, 100%, and 98% mortality against female *B. germanica* at 1 mg/♀, respectively. Among the constituents identified in basil, pennyroyal and spearmint oils, insecticidal activity of pulegone was the strongest against male and female *B. germanica*.

**key words**: Lamiaceae, insecticidal activity, fumigant and contact bioassay, *Blattella germanica*, pulegone
Application of Insect Growth Regulator (IGR) insecticides for controlling 
_Frankliniella occidentalis_

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최근 이상기후로 인한 총채벌레 발생 증가와 Neonicotinoids계, Pyrethroids계, Spinosyns계, Avermectins계 약제의 과다 살포, 중복 살포로 인한 저항성 발달로 총채벌레 방제가 어려운 상황이다. 본 연구에서는 총채벌레의 약제저항성 관리 및 효율적인 방제전략을 세우기 위한 기초 연구로 곤충성장저해제(insect growth regulator, IGR)의 적용 가능성을 검토하였다. 꽃노랑총채벌레 알, 1령 약충, 2령 약충, 성충으로 나누어 시험 약제를 처리하고, 조사는 약충의 경우 168시간까지 생존수, 알과 성충은 144시간까지 생존수와 부화 약충수를 조사하였다. 조사결과 클로르플루아주론 유제는 1령 약충, 2령 약충에 대하여 접종 168시간 후 각각 100%, 80%의 방제효과를 나타내었다. 또한 시험약제를 성충에 처리 시 산란에 대한 영향도 확인할 수 있었다.

본 연구결과를 통해 곤충성장저해제의 꽃노랑총채벌레 령기별 적용 가능성을 확인할 수 있었으며, 총채벌레 적용약제의 계통을 다양화하여 저항성 관리에도 도움이 될 수 있다고 판단된다.

검색어 : 꽃노랑총채벌레, 곤충성장저해제, 저항성 관리

Evaluation of a Botanical Insecticide on _Grapholita molesta_ (Busck)

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_Grapholita molesta_ (Busck) (Lepidoptera: Tortricidae) is an important pest of apple, peach, plum, etc. Growers use synthetic chemical insecticides to manage this pest, but _G. molesta_ have developed an insecticide resistance. As botanical insecticides have been rarely studied against _G. molesta_, we assessed relative toxicity of azadirachtin (azatrol 10 mL/L) in comparison with λ-cyhalothrin (6.7 mL/20L) in residual assays using both glass scintillation vial coated with the insecticides and apple fruits dipped in the insecticide solutions against first instar larvae (<5 h old) of _G. molesta_. Azadirachtin showed highest corrected morality of 96.7% at 8h followed by 63.3% in λ-cyhalothrin in the scintillation vial. On apple dipped in the insecticide solutions, no significance in corrected mortality was found between azadirachtin and λ-cyhalothrin. Thus azadirachtin can be used as a botanical insecticide for the management of _G. molesta_.

Key words : oriental fruit moth, neem, apple, peach
**P111**

**Paraticism of natural parasitoids of *Phyllocnistis citrella* in citrus orchards in Jeju, Korea**

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본 연구는 감귤의 해충인 과일나방의 기생성 천적의 종류와 기생률을 조사하기 위하여 수행하였다. 2013~2014 제주 감귤원에서 발견된 과일나방 기생봉 천적은 총 7종이 발견되었다. 그 중 종범과에 속한 *Sympiesis striatipes*가 73%, *Quadrastichus* sp.가 22%로 대부분을 점유하였다. 나머지 종은 *Neochrysocharis* sp., *Ageniaspis* sp., *Pnigalio* sp., *Holcopelte* sp., *Trichomalopsis* sp. (*Pteromalidae*) 등이었다. 천적의 평균 기생률은 관행재배에서 10.7%, 무농약 과원에서는 32.2%를 나타냈다.

검색어: 과일나방, 천적, 감귤, 기생률, 기생봉

**P112**

**Response of *Frankliniella occidentalis* to Three HIPVs in Y-tube Olfactometer**

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The western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), is an important pest of horticultural and agricultural crops worldwide. The repeated use of chemical insecticides resulted in the development of insecticide resistance. We evaluated response of *F. occidentalis* to three synthetic herbivore-induced plant volatiles (HIPVs), methyl salicylate, methyl anthranilate, and nonanal known as attractants of thrips’ natural enemy, in Y-tube olfactometer. Mated fed adult females of *F. occidentalis* showed lowest response rate to methyl salicylate than methyl anthranilate, and nonanal. These results show that methyl salicylate may act as repellent to *F. occidentalis*, and can be used as a component of push-pull strategies for the management of *F. occidentalis*.

**Key words:** repellent, thrips, methyl salicylate, methyl anthranilate, nonanal
전국 136개 시군에 있는 690개소 벼 관찰포에서 12종의 주요 해충을 2017년도 벼 주요해충의 발생정도는 전년 대비 96% 수준으로 유사하였지만, 평년대비는 56% 수준으로 발생이 낮은 경향임을 확인하였다.

검색어: 벼 주요 해충, 발생현황

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Predation capacity and interspecific competition of predatory mites, *Stratiolaelaps scimitus* on *Frankliniella occidentalis*

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스키미투스응애(*Stratiolaelaps scimitus*)는 토양에서 서식하는 해충의 포식성 천적으로 알려져 있으며, 꽃노랑총채벌레(*Frankliniella occidentalis*)와 아메리카잎굴파리(*Liriomyza trifolii*)의 번데기를 친환경적으로 방제하는 데 이용되고 있다. 본 연구에서는 꽃노랑총채벌레의 유충, 번데기, 성충을 대상으로 스키미투스응애의 포식량을 조사하였고, 총채벌레의 번데기에 가해하는 천적인 곤충병원성 선충(*Steinernema carpocapsae* GSN1 strain과 *Heterorhabditis bacteriophora* Hamyang strain)과의 종간경쟁에 대해서도 시험을 수행하였다. 스키미투스응애는 꽃노랑총채벌레의 유충, 번데기, 성충을 하루에 6마리, 3마리, 4마리 정도 포식하는 것으로 조사되었다. 스키미투스응애는 주로 토양에서 서식하기 때문에 총채벌레의 유충과 성충을 접촉할 기회는 많지 않지만, 접촉만 이루어진다면 하루에 4~6마리 정도는 포식할 수 있음을 알 수 있었다. 또한 총채벌레의 번데기에 가해하는 경우를 내려진 곤충병원성 선충과 스키미투스응애의 종간경쟁을 조사한 결과 스키미투스응애는 곤충병원성 선충의 감염충을 포식하지 않았으며, 역시 곤충병원성 선충도 스키미투스응애에 가해하지 않았다. 두 천적을 동시에 꽃노랑총채벌레 번데기에 처리한 후 기생력과 포식력을 알아본 결과, 스키미투스응애의 포식활동이 더 높았다.

검색어: 꽃노랑총채벌레, 천적, 스키미투스응애, 곤충병원성 선충, 종간경쟁
Oviposition characteristics of *Metcalfa pruinosa* from *Robinia pseudoacacia* to develop the monitoring method

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*Metcalfa pruinosa* was first reported in 2009 in Gimhae persimmon farms in Korea, and in Chungnam province in 2011, they first occurred in Dangjin and Taean. *M. pruinosa* adults are known to lay eggs among the crevices beneath the bark of the host plants, and they are reported to lay mainly on *Robinia pseudoacacia* trees. However, in order to solve the problem that the time and effort are too much to investigate by moving the 10 cm branch of *R. pseudoacacia* and removing the whole bark, we investigated the number of wintering eggs at different parts of branches from *R. pseudoacacia* and surveyed occurrence of them in Chungnam province.

14.5 times and 5.4 times more eggs were observed in the hair tissues of the twigs and thorns bases than the surface of *R. pseudoacacia* trees, respectively. There was no difference in the number of branches according to the thickness of branches. *M. pruinosa* in Chungnam province were mainly occurred in Taean, Geumsan and Dangjin, and showed patterns that occurred mainly in highways.

**Key words:** *Metcalfa pruinosa, Robinia pseudoacacia, Oviposition characteristics, Monitoring method*

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Insect Monitoring in Major horticultural crops

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기후변화에 따른 주요 해충 발생 추이를 보고자 시설토마토, 노지고추, 복숭아, 포도에서의 해충 발생 및 밀도를 조사하였다. 조사는 작물의 주산지를 중심으로 2015년부터 시작하여 현재까지 조사 진행 중이며, 본 결과는 2017년 조사를 토대로 작성하였다. 토마토는 온실가루이, 총채벌레, 아메리카잎굴파리 등 3종의 해충이 발생하였으며 특히, 가루이와 총채벌레는 4월 하순부터 밀도가 증가하기 시작하여 5월 하순경에 최성기를 보였다. 고추는 6월 중순부터 총채벌레, 진딧물, 가루이의 발생이 증가하기 시작하여 6월 하순에 가장 밀도가 높게 나타났다. 포도는 예루비고리장난 노린재가 모든 농가에서 발생하여 주요 해충으로 판단되며, 총채벌레는 여름 이전에 고밀도를 보였으나 재배에 영향을 줄 정도의 피해는 보이지 않았다. 복숭아는 복숭아순나방, 진딧물, 총채벌레 등이 관찰되었고 복숭아순나방과 총채벌레는 모든 농가에서 높은 밀도를 보였다. 같은 지역 내에서도 농가 간에 차이가 컸으며 이는 농가마다 방제 시기와 방법에서의 차이로 보여 진다.

**검색어:** 토마토, 고추, 복숭아, 포도, 해충발생
Investigation on the insecticidal effect of thrips registered insecticide on the crysanthemum

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The thrips, a small sucking insect, is a pest that damages various crops, including chrysanthemum, rose, and pepper. They also act as vectors for viruses such as TSWV and CSNV. The application of insecticides, such as Acetamiprid, Acetamiprid+Spinetoram, Acrinathrin, Benfuracarb, Buprofezin+Thiamethxam, Chlorfenapyr+lothiandin, Chlorfenapyr+Imidacloprid, Enamectin+Benzaote, Imidacloprid, Thimethoxam, and Chlorfenapyr, was evaluated on thrip infestation. The study concluded that the insecticidal efficacy of the insecticides varied, with Chlorfenapyr showing the highest efficacy. The research focused on the insecticidal potential of these registered insecticides on chrysanthemum, with Chlorfenapyr showing the highest efficacy.

Biological characteristics of Telenomus spp. (Hymenoptera: Scelionidae), egg parasitoids of Ricania spp. (Hemiptera: Riciiidae)

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The study investigated the biological characteristics of Telenomus spp., egg parasitoids of Ricania spp., from 2015 to 2017 in 29 regions across South Korea. Telenomus spp. were observed in 19 regions, while Ricania spp. were present in 29 regions. The study also examined the parasitoid's egg development and behavior. The parasitoids' developing period ranged from 20.0 to 26.2 days, with the highest hatch rate occurring between 2 and 4 hours after the light was turned on, and the lowest hatch rate occurring after the light was turned off. The parasitoids were found to be effective in controlling thrips populations, making them valuable biological control agents.
**Poster Presentation**

**P119**

**Repellent and attractive responses to yellow tea thrips, *Scirtothrips dorsalis* of five-flavor magnolia vine, *Schisandra chinensis* (Turcz.) by yellow fluorescent lamp and *p*-anisic acid methyl ester**

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오미자를 가해하는 여러 해충 중 과피를 가해하는 볼록총채벌레를 대상으로 황색등에 대한 기피반응과 유인제에 대한 유인반응을 2017년 5월부터 8월까지 경북 문경시 동로면 소재 유기전환, 무농약, GAP 및 유기농 재배지에서 조사하였다. 황색등을 처리한 평지 및 경사지 모두에서 볼록총채벌레의 기피반응을 확인할 수 없었고 꽃노랑총채벌레의 유인제로 사용하고 있는 *p*-anisic acid methyl ester에 대한 유인반응 또한 대조구와 비교했을 때 효과가 없는 것으로 조사되었다. 이러한 결과는 Derksen et al. (2016)이 언급한 것처럼 볼록총채벌레가 주행성(diurnal) 해충임을 의미하며 *p*-anisic acid methyl ester가 아닌 오미자가 발산하는 다른 향기물질(plant violates)을 이용한 유인제나 수컷이 방출하는 집합페로몬을 활용한 트랩 개발이 필요함을 제시하고 있다. 이러한 트랩 개발은 볼록총채벌레의 효과적인 예찰 및 대량포획에 도움이 될 것으로 판단된다.

검색어: 오미자, 볼록총채벌레, 황색등, 유인제, 기피 및 유인효과

**P120**

**Susceptibility of field populations of *Plutella xylostella* and *Spodoptera exigua* to four diamide insecticides**


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The present study evaluated the susceptibility of field populations of *Plutella xylostella* and *Spodoptera exigua* larvae to four diamide insecticides—chlorantraniliprole, cyantraniliprole, cyclaniliprole, and flubendiamide. All the four diamide insecticides induced 100% mortality in the populations from Seongju (SJ) and Geochang (GC) when treated at a concentration recommended for *P. xylostella*. However, a very low insecticidal activity was observed in the population from Pyeongchang (PC) with 42.3% 3 d after treatment with chlorantraniliprole. Further, the populations of *S. exigua* from Cheongju (CJ), Jindo (JD), and Yeonggwang (YG) were not completely controlled by the 4 diamide insecticides. A comparison of susceptibility of *S. exigua* larvae to chlorantraniliprole between 2014 and 2017 showed that chlorantraniliprole induced 100% mortality in all populations in 2014, whereas a very low insecticidal activity was observed among the populations in 2017. This study can serve as a basis to control pests effectively using diamide insecticides.

**Key words**: *Plutella xylostella, Spodoptera exigua*, Chlorantraniliprole, Cyantraniliprole, Cyclaniliprole, Flubendiamide
Establishment of direct injection system for artificial retention of *Bursaphelenchus xylophilus* to *Monochamus alternatus*

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Pine wilt disease (PWD) induced by the pinewood nematode (PWN), *Bursaphelenchus xylophilus*, is a great threat to pine forests in Europe and East Asia. Identification of interrelation between *Monochamus* spp., the major vectors of PWD and PWN is the key factor for effective control of PWD because PWN is transmitted to healthy pine trees only by *Monochamus* vectors. In this study, direct injection system is designed to apply PWN artificially to *M. alternatus* just before emergence to adults. After injection of PWN (300~500 nematodes in 10 μl of 1X PBS) using adapted glass pipets, the survival rate of *M. alternatus* and detection rate of live PWN were 80.0% and 68.8% at 168 hr respectively. As a result, we demonstrated the artificial injection methods of nematode to *Monochamus* vectors for further study of coeffect between vectors and specific stage of PWN including 3rd stage dispersal juvenile.

**Key words**: Injection, *Bursaphelenchus xylophilus*, *Monochamus alternatus*

Nematicidal activity of alkyloxyalcohol against pine wood nematode

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Pine wood nematode (PWN), *Bursaphelenchus xylophilus* causes devastating damage to pines worldwide. To develop new agent for controlling PWN, alkyloxyalcohols(A-H) were synthesized and nematicidal activity was tested against PWN. As a control, monochamol, which reported to have nematicidal activity was also tested. The nematicidal activity was different according to carbon chain length in compounds. LC$_{50}$ values of F, G and H were as same as that of monochamol. However A-E which have shorter carbon length than F-H showed weak nematicidal activity.

**Key words**: alkyloxyalcohol, *Bursaphelenchus xylophilus*, nematicidal activity, Structure-Activity Relationship
**A synergist for attracting Stathmopoda masinissa**

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*Stathmopoda masinissa* is one of the most serious lepidopteran pests which damaging the fruit of persimmon. Its pheromone composition has been identified as (E4,Z6)-4,6-hexadecadienyl acetate (E4,Z6-16Ac) and (E4,Z6)-4,6-hexadecadien-1-ol (E4,Z6-16OH). We evaluated electrophysiological response of (E4,Z6)-4,6-hexadecadienal (E4,Z6-16Ald) and attractiveness of E4,Z6-16Ald by combination of two pheromone components. E4,Z6-16Ald evoked electrophysiological responses as same to that of two pheromones. The lure combined with E4,Z6-16Ald and two pheromone components attracted more male *S. masinissa*.

**Key words:** *Stathmopoda masinissa*, synergist, pheromone, (E4,Z6)-4,6-hexadecadienal

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**Economic effect on import prohibition of the buff-tailed bumblebee, Bombus terrestris**

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For economic effect on an import prohibition for the buff-tailed bumblebee, income of the bumblebee products, function, economic effect of pollinating insects and bumblebee were analyzed. The largest incremental gain was observed when using domestic bumblebees. Incremental revenue showed a larger incremental revenue in pollination than artificial pollination, the cost of artificial pollination was lowest for incremental cost, followed by domestic bumblebees, honeybees and imported bumblebees. Consequently, higher economic value can be achieved when domestic bumblebees and honeybees are used. According to this study, as it is used to make policy decisions on the prohibition of import of buff-tailed bumblebee, other alternative plan can be utilized due to its import prohibition.

**Key words:** *Bombus terrestris*, buff-tailed bumblebee, distribution expansion, economic impact evaluation, naturalization, pollinator
Distribution of insect pests according to different temperatures and humidities in tomato smart farm

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Tomatoes are known to grow well at a moderate level of humidity, and tomato plants are usually grown in greenhouses. In recent years, with the development of ICT (Information, Communication, and Technology), it is possible to remotely control temperature, humidity, 

CO₂, etc. and thus efficiently manage the environment of the plants, making it possible to reduce effort and time while maintaining the growth environment. This study was conducted to investigate the distribution of insect pests according to different temperatures and humidities in tomato greenhouses and smart farms. The results showed that the distribution of insect pests varied depending on the location within the greenhouse, and small potato weevils were more common in the lower part of the greenhouse, while tobacco hornworms were more common in the central area and higher parts. The search terms used were: smart farm, tomato, tobacco hornworm, small potato weevil.

Evaluation of Attractants and Traps for the Monitoring of Drosophila suzukii (Diptera: Drosophilidae)

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Bactrocera suzukii is a pest that is not considered as serious in Korea, and there is limited research on its biology and monitoring. However, the current study aimed to evaluate attractants and traps for the monitoring of Bactrocera suzukii in apple orchards and blueberry orchards. The results showed that the ACV + wine and Dreves traps were more effective in catching Bactrocera suzukii. The search terms used were: Bactrocera suzukii, monitoring, effective attractant, effective trap, screening experiment.

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Insecticide Resistance Differences by Carbofuran Application Methods

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Toxicities of Carbofuran showed different patterns by three application methods, Drench (as systemic effect), Leaf dipping (as contact and systemic effects) and Topical (as contact effect) applications. LC₅₀ dropping pattern was L-shape in Drench, low slope line in Topical and intermediate of them in Leaf dipping. Drench application was the most Carbofuran treatment method to Brown planthoppers. Dropping patterns of LC₅₀ were almost same between resistant and susceptible strains. The checking time of Carbofuran toxicity was suggested to be 2nd day after application by SD analysis of mortality. Resistance ratios were peak on 3rd day after application in Drench, 4th day (Susceptible) and 5th day (Resistant) in Leaf dipping and showed steady increase line pattern in Topical application.

Key words: Carbofuran, application methods, resistance, pattern, mortality

Characterization of the voltage-sensitive sodium channel and acetylcholinesterase genes from the small hive beetle for efficient control

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Small hive beetle (Aethina tumida) (SHB) is an invasive species to most northern hemisphere countries, including Korea. In an attempt to obtain basic information for efficient management of SHB, genes encoding conventional insecticide targets [voltage-sensitive sodium channel α-subunit (VSSC) and acetylcholinesterase (AChE)] were annotated and characterized following the analysis of whole transcriptomes of adults and larvae. A single VSSC gene was identified but no apparent mutations associated with pyrethroid resistance were detected. Genes encoding two AChEs (AtAChE1 and AtAChE2) were identified from the SHB transcriptome. AtAChE1 was determined to be the main catalytic enzyme, thereby being a toxicologically more relevant target. No apparent mutations associated with resistance to organophosphorus and carbamate insecticides was identified in the AtAChE1 gene, whereas the S238G mutation, originally identified from the Colorado potato beetle, was detected in the AtAChE2 gene.

Key words: Small hive beetle, Voltage-sensitive sodium channel, Acetylcholinesterase, insecticide, resistance
The Physical Control of *Bradyisia agrestis* by Using Sticky Trap and Substrate Cover in Greenhouse-grown Strawberry

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After setting up a sticky trap in the greenhouse where *Bradyisia agrestis* was occurring, it was found that the number of adults captured was significantly reduced compared to the controls. When applying different substrates to the soil, the results showed that the highest number of adults was captured on the white film, while the least number was captured on the black film and red film. The results also showed that the use of a combination of sticky traps and substrate covers was effective in reducing the population of *Bradyisia agrestis*.

Search terms: strawberry, sticky trap, substrate cover

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Ocurrence and Environment-friendly Control of *Eurytoma maslovskii* in Japanese Apricot (*Prunus mume*)

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The study aimed to determine the occurrence of *Eurytoma maslovskii* in Japanese apricots and to develop an environment-friendly control method. It was found that the incidence of the pest was higher in apricots stored in open fields compared to those stored in cold storage. The study also showed that the use of different substrates and storage conditions had a significant impact on the incidence of the pest. The results also indicated that the use of red film and substrates as a protective layer was effective in reducing the incidence of *Eurytoma maslovskii*.

Search terms: Japanese apricot, *Eurytoma maslovskii*, substrate cover

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Control strategies using EFAM and natural enemy when cultivating autumn-type leaf Perilla

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This study was performed to establish the control strategies effectively using Eco-friendly agricultural materials (EFAM) and natural enemy when cultivating autumn-type leaf perilla and to investigate the population densities of seasonal major pests such as *Tetranychus urticae* (two-spotted spider mite, TSSM), Broad mite (*Polyphagotarsonemus latus*), *Aphis egomae*, and *Pyrausta panopealis*. TSSM showed the occurrence in the seedling stage from August to the end of September and controlled using EFAM in the nursery. Broad mites had a low occurrence in October, December, and the following year showed the density of two or more leaves per leaf from February. *Aphis egomae* was locally prevented around the area of occurrence, and it showed more than five per leaf in October. *Pyrausta panopealis* seemed to occur from August to September. *Aphis egomae* is control using high-toxic EFAM before the overwintering and prevents it from using banker plants planted barley in the winter. *Pyrausta panopealis* is protected by biological pesticides in August registered in the leaf perilla.

**Key words**: leaf perilla, broad mite, population density, pesticides, EFAM.

Assessment of pesticides efficacy against the nymph of Citrus flatid planthopper, *Metcalfa pruinosa*

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Eighty kinds of pesticides registered in the peach and leaf perilla were assessed the efficacy against the 4th nymph stage of citrus flatid planthopper. Plant of Sharon, host plant preferred by citrus flatid planthopper, was cut from 5 to 7 cm and dipped 10 seconds into recommended concentrations of pesticides, respectively, and then dried naturally for the 30 minutes. New shoot of Plant of sharon treated pesticides and 10 to 15 final nymphs of citrus flatid planthopper put together in the 50㎖ tube and the number of live nymphs was investigated after 48 hours. Pesticides showing mortality over 90% were seven, namely, bifenthrin EW, Rhamda-cyhalothrin EC, Clothianidin SC, Benfuracarb SG, Chloropyrifos WP, Bifenthrin+methoxypenozide SC, Chloropyrifos+imidacloprid WP. When the forest surrounding the peach and leaf perilla was occurred and damaged by citrus flatid planthopper, the use of these pesticides is judged to be effective in the control of this pest.

**Key words**: citrus flatid planthopper, *Metcalfa pruinosa*, pesticides, peach, leaf perilla, control
Establishment of Spray Standards for Major Pest Control of Chinese Cabbage Using Drones

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Drone to establish spray standards for major pest control of Chinese cabbage using drones are presented. The height of the drone (3, 4, 5m), flight speed (3m/sec, 4m/sec) and downwind speed, spray volume, particle size, and number of droplets under spraying conditions were investigated. Furthermore, the major pests of Chinese cabbage, such as the cabbage looper, the diamondback moth, and the tobacco hornworm, were treated with four types of pesticides for effectiveness and residual effects. The aerial application method for Chinese cabbage major pests is proposed to use a solution of 20% of the pesticides in the air at 3 meters height and 3 meters/second speed.

The Trapping Effect of *Ricania shanthungensis* (Hemiptera: Ricaniidae) Adults with Yellow Sticky Traps Containing Attractants

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The trapping effect of yellow sticky traps on adult *Ricania shanthungensis* (Hemiptera: Ricaniidae) in a Chinese cabbage field was investigated. The traps were placed in the field for two years and the number of trapped insects was counted. The traps were more effective for catching the adult insects than the control traps. The results showed that the traps were effective in catching the adult insects of *Ricania shanthungensis* in the field.
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**Selection of Environmental Friendly Pesticides against to *Metcalfa prunosa* Damaging in Ginseng Field**

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The citrus flatid planthopper *Metcalfa prunosa*, an invasive species causes serious damages to field crops, including sweet persimmon, soybean, maize, especially ginseng (*Panax ginseng* C.A. Meyer). We selected six chemical pesticides and one environmental friendly pesticide made from the mixture of derris extracts, citronella oils, and cinnamon extracts in laboratory. These pesticides showed over 90% of control effect in open ginseng field. This study was carried out with the support of the cooperative research program for RDA (project No. PJ0124992018), Republic of Korea.

**Key words**: Control, environmental friendly, ginseng, *Metcalfa prunosa*, Pesticide

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**Ethyl formate fumigation to avoid hazardous methyl bromide released post-fumigation on imported grapes**

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Methyl bromide (MeBr) is well-known as a hazardous chemical to exposed fumigators and related workers as well as a ozone depletion chemical. According to recent report in USA and Korea, when MeBr fumigated on orange and grape at low temperature (<10°C), absorbed MeBr on fruits was slowly released to workplace. To replace MeBr practices urgently, ethyl formate (EF) fumigation is considered safer to worker (TLV of EF = 100 ppm compared to MeBr's = 1 ppm) and free from residual problem. We reports confirmative liquid EF (FumateTM) with N2 trials, which is cost-effective and non-CO2 gas emitted, on imported grapes. The 4hr-fumigation of 70 gm-3 of EF (CTP > 114 gh-3) in scale-up chamber (10m3) fumigation (20% l.r.), showed efficacies to many kinds of insect pests, non-phytotoxic damage, providing safer guideline at workplace.

**Key words**: Ethyl formate, Alternative to methyl bromide, Hazardous to workers, Imported grape
Applicable uses of ethyl formate and phosphine, as alternative of methyl bromide, on imported nursery plants

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The current protocols of methyl bromide (MeBr) fumigation on imported nursery plants, which are seriously infested with quarantine mealy bugs and scales, could be reevaluated because there were no limited uses of loading ratio, packing types etc. Another emerging issues is that the workplace health issues on MeBr fumigation are related with poor ventilation etc as well as well-known phytotoxic damages on them. In previous report, we have evaluated the efficacies of ethyl formate (EF) and phosphine (PH3) on different types of mealybugs. Herein, the phytotoxic damages of EF and PH3 on Alocasia, Sansevieria, Cactaceae and Croton genera were evaluated in terms of chlorophyll contents, color changes etc. This study showed that EF and PH3 fumigation on imported plants could be applicable to replacement of MeBr with further confirmation trials.

Key words: Ethyl formate, Phosphine, Nursery plants, Alocasia, Sansevieria, Cactaceae, Croton

Characteristics of insect pests infesting organically cultivated grains and soybeans in paddy-upland rotation and continuing upland fields

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The occurrence characteristics of major insect pests infesting organically cultivated maizes, millets, sorghums, and soybeans were surveyed from 2015 to 2017 in paddy-upland rotation and continuing upland fields. In grain fields, the main damage of maizes and sorghums was caused by Ostrinia furnacalis and Helicoverpa spp. The occurrence pattern of O. furnacalis was 3 times and that of Helicoverpa spp. was 3-4 times. In soybean fields, Riptortus clavatus was the most important, but the pest was not observed at geumhwajaerae and bongeui varieties. Interestingly, the more high the invasive rate of lepidopteran larvae was, the more low the yield of maizes and sorghums was. The surveyed results indicate that the focused management on lepidopteran larvae or hemipteran pests in maizes and sorghums or soybeans cultivated in paddy-upland rotation and continuing upland fields is an important strategy.

Key words: Helicoverpa spp., maize, Ostrinia furnacalis, paddy-upland rotation field, sorghum
Occurrence and Selection of Acaricides of Bulb Mite, *Rhizoglyphus robinii* on Northern-Garlic in Chungbuk Province

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The impact of *Anononeura mori* on the mulberry damage

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The mulberry for production of mulberry fruit, found the damage and quantity according to the level of damage by the *A. mori*, and through regression analysis, we set up a economic injury level. The level of damage by *A. mori* was to be artificially adjusted, for 2 percent, 5%, 8 percent, and 11 percent of leaf damage. Investigate, From May 31 to June 14, they compared the damage to each damage level and the growth and development and quantity. The survey found that the more damage level, the more severe the damage. The ratio of damage fruit was 5.1 percent, 11 percent, 13.2 percent, 23.9 percent, respectively. And the quantity was reduced by about 33% from 11 percent to 2,387 g/tree compared to the 2 percent to 3,557 g/tree. There's no difference in the damage caused by the sclerotium disease, and the growth and development, such as the length of the tree, the length of the branches, and the thickness of branches. The relationship between the damage level and the ratio of damage fruit was able to obtain relations with the linear regression, $Y = 2.129552 X +0.569663(R^2 = 0.98)$. It's the result of an analysis, which analyzed the damage level's relationship with the ratio of damage fruit have a high correlation rate. Therefore, It's about the ratio of the quantity losses is 5 percent, the ratio of damage leaf is 2.08 percent. If the ratio of damage leaf is more than 2.08 percent, the damage will be required the control. It is judged.

Key words: *Anononeura mori*, mulberry fruit, mulberry, Economic injury level
Sex Pheromone Traps Effect of Trapping Tobacco Cutworm (*Spodoptera litura* (Fabricius)) by Installing Tomato Greenhouse and Glasshouse

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The tobacco cutworm, *Spodoptera litura* (Fabricius) is serious pest that hurts tomato crops, active long time of the year. Without pesticide applications, sex pheromone delta traps through experiment first and second half setting during cultural seasons in glasshouse and greenhouse. We investigated captured number of *S. litura* both in and out side of the two type of tomato cultivated greenhouse. As a result of investigation, captured number of *S. litura* showed the wave and three high peak typed graph throughout 10 months experiment. First time expression of *S. litura* was late April in outside installed traps and after that occurrence rate increased gradually until late August. In september, the rate decreased remarkably to middle November in both in and out side treated traps. The result also expressed that captured average number of *S. litura* in inside of the greenhouse were 8~10 units, and were 15~20 units in outside treated traps. Simultaneous installation of internal and external sex pheromone traps succeeded in eliminating a considerable number of *S. litura* male moths, and the number of larvae was expected to be considerably reduced. Consequently in the experiment, captured male number of *S. litura* were about 220 units in outside, on the other about 80 of *S. litura* captured in inside installed traps.

**Key words**: Spodoptera litura, Sex pheromone, Tomato, Glasshouse, Greenhouse

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Attractive Effect of Stink Bugs by the Rocket Trap Placed Sites in Agricultural Fields

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 Conj, 팥, 들깨 및 매실원에서 집합페로몬 로켓트랩에 의한 톱다리개미허리노린재의 유인효과를 조사하였다. 콩포장에서 톱다리개미허리노린재와 썩덩나무노린재의 집합페로몬 (aggregation pheromone; AP)를 각각 및 조합하여 로켓트랩에 주입하여 콩포장 내 10, 5 및 0m(콩포장 가장자리) 지점과 콩포장 바깥 5m(휴반) 지점에 설치한 결과 톱다리개미허리노린재의 유인수는 콩포장 바깥 5m(휴반)에서 가장 높았으며, 다른 설치지점간에는 차이가 없었다. 이러한 경향은 썩덩나무노린재의 유인수도 같은 경향을 나타내었다. 또한 톱다리개미허리노린재와 썩덩나무노린재의 AP를 각각 및 조합하여 로켓트랩에 주입하여 콩포장 내 5m, 콩포장의 가장자리, 들깨포장 내 5m, 팥과 들깨포장의 경계, 팥포장 바깥 5m 지점에 설치하여 톱다리개미허리노린재와 썩덩나무노린재의 유인수를 조사한 결과 이들 노린재류의 유인수는 팥 포장 5m 지점에서 가장 높았다. 한편, 매실원에서 집합페로몬 로켓트랩의 설치지점에 따른 노린재류의 유인수는 톱다리개미허리노린재는 가장자리에서 가장 많았고, 다음은 과원내=과원바 5m=과원바 10m=과원바 15m=과원바 20m 순으로 나타났으며, 썩덩나무노린재는 가장자리에서 가장 많았고, 다음은 과원바 5m=과원바 10m=과원바 15m=과원바 20m 순으로 나타났다. 이러한 결과로 보아 농작물 재배포장에서 집합페로몬에 의한 노린재류의 유인효과는 로켓트랩의 설치지점과 밀접하게 관련이 있다는 것을 알 수 있었다.

**검색어**: 노린재류, 집합페로몬, 로켓트랩, 설치지점, 유인
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Cryptic mealybug, *Pseudococcus cryptus* Hempel and its natural enemies on Jeju island

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Cryptic mealybug, *Pseudococcus cryptus* Hempel is a serious pest in Jeju Island. It is a small, cryptic mealybug that is difficult to control due to its natural enemies. The natural enemies of this mealybug include the ichneumon wasp *Anagyrus* sp., the parasitoid *Golamudiplosis japonicus* and the ladybug *Propylea japonica*. The ichneumon wasps are active in the summer, while the wasps and ladybugs are active in the fall. The disease *Paecilomyces* sp. is also present in the area, which is active in the rainy season. The Cryptolaemus montrouzieri was introduced to farmers as a natural enemy of the mealybug. Keywords: Cryptic mealybug, natural enemies, Jeju Island.

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Development of integrated pest managemant manual on brussels sprouts in Jeju, Korea

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Brussels sprout production is a major agricultural industry in Jeju Island. The objectives of this study were to determine the pest and disease management strategies for Brussels sprout production in Jeju Island. The annual occurrence of pests and diseases was monitored from 2016 to 2017. The pest management manual was prepared based on the results of the monitoring. The pest management manual includes the monitoring of pests and diseases, and the application of pesticides and other control measures. Keywords: Brussels sprouts, pest management, Jeju Island.
Optimization of entomopathogenic nematode (EPN) solid culture medium and production conditions

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In order to develop solid mass cultivation technology that maximizes insecticide of entomopathogenic nematode (EPN) isolated from Korea, we have studied the optimization of solid culture medium and production conditions. The optimized conditions from the harvest yields and the insecticidal activity against the Galleria mellonella larvae were yeast extract 2.0%, soybean flour 20%, whole milk powder 3%, olive oil 5% and egg yolk 5%. It was also found that the optimum condition of the carrier (polyurethane) content was about 8-12%, the culture time of symbiotic bacteria was about 48 hours, and the inoculation concentration of nematode was 4,000-5,000 per g medium. And the optimal harvesting point in solid culture conditions was confirmed after 12 days of inoculation.

Key words: entomopathogenic nematode, insecticidal activity, solid culture, culture condition, mass production

Determination of control timing of Carposina sasakii in organic jujube orchards

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Currently, Carposina sasakii (peach fruit moth) is considered economically important pest in organic jujube orchards. However, until now, research has not been conducted to control C. sasakii. The control period is very important for moth larvae to contact organic materials. Therefore, this study were conducted to determine when control using organic materials selected in 2017. In the method, parafin oil selected in 2017 was treated seven times at interval of seven days, and each treatment interval was seven days until 7th treatment. As a result, when the control started at the early to mid July, the control values were about 75%, and when the control started at late July to mid August, the control values were over 85%. However, when the control started after mid August, the control value was less than 30%. Therefore, in order to effectively control C. sasakii, control must be started by early August.

Key words: jujube, Carposina sasakii, control timing
Effect of some lichen extracts on insecticidal activities and development the larvae of *Aedes albopictus*

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The effect of the ionization energy on the common house mosquito, *Culex pipiens*, pupa was investigated as the hatching rate, longevity and detoxification enzyme activity. The longevity of adult emerging in the pupa decreased depending on the exposure dose of Gray (Gy) in *C. pipiens*. The hatching rate of the F1 generation egg derived from *C. pipiens* pupa treated up to 70 Gy did not show any difference with the control, but the eggs did not hatch 100% at 120 Gy exposure. These results showed that *C. pipiens* was sterilized at 120 Gy. Several detoxifying enzyme (GST, non-specific esterase and MFO) activity of *C. pipiens* adult emerged from pupa irradiated with 120 Gy was investigated. The difference in activity was observed in female than in male irradiated with electron beam.

As a result, electron beam irradiation seems to affect enzyme activity as well as induce infertility of *C. pipiens*.

**Key words**: *Culex pipiens*, Electron beam, Hatchability, Detoxification enzyme
Evaluation of the neonicotinoid pesticides on *Monochamus alternatus* (Coleoptera: Cerambycidae) by oral injection in laboratory

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SulsumyehunLOSSO is an important insect for spruce beetle and the population is controlled by aerial or ground spraying of contact pesticides. This study aimed to identify appropriate insecticides for the control of *SolsumyehunLOSSO* by oral injection of neonicotinoid insecticides at 2,000 ppm. We orally injected 2 μL of each insecticide into *SolsumyehunLOSSO* and measured the symptoms of ingestion toxicity. After 30 minutes, Clotianidin SL (100%), Thiamethoxam DC (73.3%) showed higher ingestion toxicity compared to Dinotefuran SL (46.7%), Imidacloprid DC (0.0%). The LT₅₀ was 54.7 hours for males and 85.6 hours for females with Clotianidin SL, and 70.1 hours for females and 88.7 hours for males with Thiamethoxam DC. Therefore, Clotianidin SL and Thiamethoxam DC were the most suitable insecticides for the control of *SolsumyehunLOSSO*.

**Keywords:** SulsumyehunLOSSO, Oral injection, Ingestion toxicity, LT₅₀, Clotianidin SL, Thiamethoxam DC

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Tendency and analysis of pests and pathogen detection during quarantine inspection of imported plants for planting

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South Korea has implemented the WTO/SPS (International Plant Protection Convention) to prevent the import of agricultural products and pests. We extracted the data on the number of pests detected during the quarantine inspection of imported plants and analyzed the changes in pest detection rates and types of plants. The number of detected pests increased as the number of imported plants increased, and the detection rates of pests decreased for non-edible plants (from 9.8% in 2007 to 3.3% in 2017). However, the detection rates of pests increased for edible plants (from 7.9% in 2011 to 22.0% in 2017). We used the Plant Inspection Information System (PIS) to analyze the data on the detection of pests and pathogens and the types of plants. The detection rates of pests and pathogens were lower for edible plants than for non-edible plants. The detection rates of pests and pathogens were lower for edible plants than for non-edible plants. The data were analyzed using the Plant Inspection Information System (PIS) and the results were used to improve the quarantine inspection process.

**Keywords:** Plant Inspection Information System (PIS), Edible plants, Non-edible plants, Pest detection, Pathogen detection
Comparison of propagation ability and pathogenicity among 3 species of *Bursaphelenchus* in *Pinus thunbergii* and *P. koraiensis*

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 재선충속(*Bursaphelenchus*) 선충의 식물 기주체내 증식 능력 및 병원성을 비교하기 위하여 선충 3종 (이하 *Bursaphelenchus xylophilus*: Bx, *B. mucronatus*: Bm, *B. thailandae*: Bt)과 해송(*Pinus thunbergii*), 갖나무(*Pinus koraiensis*) 2종을 실험에 사용하였다. 5가지 선충 처리 조합 (①Bx+Bt, ②Bx+Bm, ③Bx+Bt+Bm, ④Bt+Bm, ⑤Bm)으로 한 본당 10,000마리씩 접종 한 후 7주 동안 외부 병징 및 선충 밀도를 조사하였다. 그 결과, Bx가 포함된 대부분 처리구에서는 5주 차에 전체 고사가 진행 되었고, Bx가 포함되지 않은 처리구는 병정이 나타나지 않았다. 예외적으로, Bx+Bm, Bx+Bt+Bm 해송 처리구에서는 7주 후에도 전체고사가 나타나지 않았다. 이 경우 선충 밀도 조사 결과, Bm이 약 42%를 차지하였으며, 이는 소나무재선충병의 병정 발현을 약화를 유도하는 역할을 하는 것으로 추정된다. 모든 처리구에서 Bx의 밀도가 가장 높았으며, Bt는 전혀 검출되지 않았다.

검색어: *Bursaphelenchus xylophilus*, *B. mucronatus*, *B.thailandae*, *P.thunbergii*, *P.koraiensis*, Interaction

Comparisons of penetration ability among 3 species of *Bursaphelenchus* into *Monochamus alternatua* and *M. saltuarius*

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소나무재선충과 근연종인 *Bursaphelenchus* 속 2종간의 매개충 채내 침입력과 경쟁력을 비교 실험하였다. 공시충은 *Bursaphelenchus xylophilus* (이하 Bx), *B. mucronatus* (이하 Bm), *B.thailandae* (이하 Bt) 선충 3종과 솔수염하늘소 (*Monochamus alternatua*)와 북방수염하늘소 (*M. saltuarius*) 2종을 사용하였다. 매개충 번데기에 선충 3종을 10,000 마리씩 단독 또는 혼합접종을 하고, 우화 후 채내 선충 개체수를 조사한 결과, 솔수염하늘소에서는 Bx, Bm, Bt가 각각 2,283마리, 1,575마리, 3,083마리로써 Bt의 침입력이 가장 높게 나타났다. Bx+Bt 처리 시에는 Bx 24%, Bt 76%, Bx+Bm 처리 시, Bx 68%, Bm 32% 비율로 조사되어 Bt>Bx>Bm 순으로 침입력이 강한 것이 확인되었다. 북방수염하늘소에서 Bx, Bm의 침입력을 비교한 결과 Bx는 2,120마리, Bm 1,730마리로 솔수염하늘소에서와 유사한 결과를 나타내었다. 이로써 선충 종간 침입력은 다양하며 이는 매개충 종과는 무관함을 알 수 있다.

검색어: *Bursaphelenchus xylophilus*, *B. mucronatus*, *B.thailandae*, 침입력, 우점도
The attraction effect verification of sex pheromone trap for the *Matsucoccus thunbergianae* male

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*Matsucoccus thunbergianae* is the main forest insect pest of the Japanese Black Pine (*Pinus thunbergii*) in the west, south and east coast of South Korea. The main damage pattern appears to be the cumulative damage over many years by the second instar fixed under the pine bark. The adult male has a pair of wings and is attracted sex pheromone emanating from the adult female so that during the mating period (Generally, middle period of March) adult male is attracted to the adult female which has no wing. Using this mating behavior from the adult male, we developed sex pheromone trap to reduce mating success rate by reducing the density of the adult male in the field. In this study, In the indoor induction experiments and the field experiments, sex pheromone trap showed high induction effect on the adult male. Thus, we expect to reduce the damage to the Japanese Black Pine by *Matsucoccus thunbergianae*.

**Key words:** *Matsucoccus thunbergianae*, Japanese Black Pine, Sex pheromone trap

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The diagnostic detection method for *Bursaphelenchus xylophilus* in the pinewood using Recombinase Polymerase Amplification (RPA)

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*Bursaphelenchus xylophilus* (*Bx*) is the main plant-parasitic nematode of the Japanese Black Pine (*Pinus thunbergii*), Red Pine (*Pinus densiflora*) and Korean Pine (*Pinus koraiensis*) in the South Korea. Until now, the nematode morphological classification or PCR method using specific marker of *Bx* were used for the diagnosis of pine wilt disease. However, both methods have a disadvantage that these take a long time to confirm the result. Thus, these methods can not be used quickly at the newly damaged regions. For above the reasons, we had been developed the diagnostic method for *Bx* combining direct gDNA extraction buffer (DAP) with Recombinase Polymerase Amplification (RPA). This method is able to directly use mixed lysates extracted from *Bx*-infected pinewood by DAP buffer as gDNA template to RPA without another process for increase gDNA yield. Together, our method is able to detect *Bx* within 20 mins.

**Key words:** *Bursaphelenchus xylophilus*, Recombinase Polymerase Amplification, Direct gDNA extraction
Phytosanitary Cold Treatment of Spotted-wing Drosophila, *Drosophila suzukii* (Diptera: Drosophilidae), in ‘Campbell Early’ Grape

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The effects of cold storage temperature and exposure duration on immature stages of spotted-wing drosophila (SWD) *Drosophila suzukii* (Diptera: Drosophilidae) on ‘Campbell Early’ grapes were examined to establish a phytosanitary control method. The immature stages (eggs, larvae and pupae) of SWD were all dead after a 6-day cold treatment at 1°C and 8-day cold treatment at 1.5 and 2°C. Small-scale tests using pupae, which were the most-cold tolerant stage, confirmed the validity of the selected temperature and exposure durations. Conversely, the 8- and 10-day at 1°C treatments showed 100% mortality, suggesting that these treatments can guarantee quarantine security against infestations of SWD on exported ‘Campbell Early’ grapes.

**Key words**: *Drosophila suzukii*, cold treatment, ‘Campbell Early’, mortality, quarantine

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Single Nucleotide Polymorphisms from Mitochondrial Genomes that Diagnose the Honey Bee Strains (*Apis mellifera ligustica*) with the High and Low Hygienic Behaviors

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The honey bee, *Apis mellifera ligustica* (Hymenoptera: Apidae), strain with a high hygienic behavior (HHB) has been bred for several years in Korea, and a diagnosis system to distinguish it from low hygienic behavior (LHB) strain has been necessitated. Thus, complete mitogenome of the two strains were sequenced through Next-Generation Sequencing technique to detect SNPs. Comparison of the mitogenome sequences from the two strains of *A. m. ligustica* have detected 23 SNPs in 11 PCGs and these were further confirmed the presence of SNPs using each 10 individuals selected randomly from each strain, indicating that these SNP markers might be useful to diagnose the honeybee strains with the HHB. Therefore, mitogenome sequences are promising genome source to detect SNP markers, particularly for inbred female iso-lines.

**Key words**: *Apis*, mitochondrial genome, Hymenoptera, hygienic behavior, SNP
Research of bio-Sugar from vegetables to supply carbohydrate sources to honeybee, *Apis mellifera* L.

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Honeybees (*Apis mellifera*) are defend on feeds for their larvae and adult bees’ healthy life. The nectar is carbohydrate source for making energy. We are extract several sugars from plants for using carbohydrate source to bee. 3 sugar source was extracted from plants (watermelon, cabbage, and mandarin). Almost sample showed high level of insecticidal rate and low level feed intake rate. We were selected 2 type of cabbage sugar syrup that low level insecticidal rate and high level feed intake rate (No 6 cabbage(+fructose) was mixed with 10% fructose and No. 7 cabbage(+pollen) was made with 10 % pollen). Cabbage sugar solution has much more impurities than purified sugar. So, No.6 and No 7 sample can do up-regulation of antimicrobial genes (apideacin, defencin, abacin, and hymenopteacin). Cabbage sugar solution has much more impurities than purified sugar. Our results suggest that up-regulation of antimicrobial genes might be involved in worker through carbohydrate impurities related immune pathways.

**Key words:** Honeybee, *Apis mellifera*, Sugar, Feed

Comparison of naturally mated and artificially inseminated *Apis cerana* queen

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Control mating is important aspect in bee breeding programs. The technique of artificial insemination is the possible one that can surely control mating of the selected drones with the virgin queen. This is the first time applied artificial insemination technique to control mating of *A. cerana* in Korea. Altogether 18 queens were artificially inseminated, and 2,000 drones of Korean *A. cerana* were used to evaluate amount of semen collection. Semen of *A. cerana* is much difficult to separate from mucus in comparing with *A. mellifera*. The average amount of semen can be collected from one *A. cerana* drone was 0.09 μl, whereas the *A. mellifera* was more than 6 times (0.58 μl semen per *A. mellifera* drone). Obtaining 1 μl of semen have to collect from 11.94 drones that successful semen ejection and have to kill 17 *A. cerana* drones. Queens artificially inseminated with 4 μl of semen (once insemination) or 8 μl of semen (twice insemination, each with 4 μl of semen) started laying egg later than naturally mated queens 5.3 and 2.5 days, respectively. The onsets of oviposition of artificially inseminated queens were 12.5 to 15.3 days. Queens received twice inseminations started laying eggs 2.8 days earlier than those received only once insemination. Artificially inseminated queens produced exclusively brood and were similar as the naturally mated ones. The brood production of the queens received once insemination with 4 μl of semen was insignificantly different than those received twice inseminations or naturally mated ones, suggesting that one artificial insemination with 4 μl of semen is favorable.

**Key words:** Artificial insemination, Insemination, Natural mating, *Apis cerana, Apis mellifera*, Semen, Honeybee
Hair loss preventing activity of a larval powder of steamed mature silkworms, *Bombyx mori*

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The mature silkworms of *Bombyx mori* L. have recently been regarded as a potential health supplement due to gaining their edibility for humans via a newly-developed steaming method by the Rural Development Administration in Korea. This study was conducted to investigate the effects of a larval powder of steamed mature silkworms (SMSP) on hair growth/loss *in vivo* in mice. Topically applied SMSP showed potent hair growth promoting activity. SMSP-treated mice showed increase in hair weight significantly compared with control mice which were not treated with SMSP. Orally administered SMSP also showed hair growth promoting activity, which was lower than that when applied topically. By elucidating the hair loss preventing activity of SMSP, this study will be helpful to increase incomes for sericultural farm households in Korea.

Key words: *Bombyx mori*, mature silkworm, hair growth promotion, hair loss prevention

Selection of supplementary feeding source on *Zophobas morio* (super mealworm) for shortening development period

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아메리카왕거저리의 사육기간을 단축과 기능성 향상을 위해 밀기울에 다양한 먹이를 보조사료로 공급하여 발육기간과 무게를 측정한 결과, 먹이종류별 아메리카왕거저리의 발육기간은 조단백질함량이 많은 배합사료와 밀기울에서 80.8일과 75.6일로 가장 짧았으며 버섯배지는 160일이상 소요되었으며 왕거의 생충율은 85%로 가장 낮아 버섯배지와 왕거는 먹이원으로 적절하지 않았다. 보조 먹이원 선발을 위해 할맥, 압맥, 배추, 백련초, 파프리카, 개똥쑥을 20~80% 밀기울에 첨가한 결과 압맥과 할맥은 정상적으로 생장하지만 백련초, 개똥쑥 혼합에서는 접종 직후부터 죽은 개체들이 출현하여 생충율이 12.9%, 10.8%로 아주 낮게 나타났으며 배추와 파프리카도 24.2~38.8%로 낮아 보조사료로 적합하지 않았다. 들깨와 콩가루 역시 생충율이 높지 않아 1, 2차 시험결과 할맥, 압맥과 메밀이 보조사료로 적합하였다.

검색어: 아메리카왕거저리, 먹이원, 보조사료
An analysis on free sucrose amount of fermented sawdust by the condition of microorganism

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The sawdust fermentation is a feeding source for the larvae of the white-blotched moth and the oviposition site for adult insects. A significant difference in larval growth was observed depending on the feeding source. The fermentation of sawdust during which the microorganisms play an important role was performed using Lactobacillus and Bacillus. In addition, KB3, LM11 strains that originated from a herbivorous insect were used to produce fermented sawdust and the growth was examined. During the fermentation process, the changes in reducing sugars were measured to investigate their relationship to growth. The glucose was detected in the sawdust treated with 6 types of microorganisms. The growth increased with fermentation, and the highest glucose content of 111.8 mg/g was observed in the KB3-treated sample after 50 days of treatment.

Development and Mating Characteristics of *Locusta migratoria* in different temperature

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*Locusta migratoria* is a large locust with strong group behavior and high adaptability to various food plants. The most suitable temperature for rearing *Locusta migratoria* was investigated in this study. The experimental temperature was set at 25℃, 27℃, 30℃, and 33℃ with 12L/12D, 65% RH, and 1,000 lux. The larval growth period from 1st to 5th instar increased from 30℃ (26.4±2.0 days) to 25℃ (46.9±1.9 days) by about 1.8 times, and from 27℃ (31.8±2.5 days) to 33℃ (30.7±2.6 days) by about 1.2 times. The body weight and size of the larvae at 30℃ were the highest among the experimental temperatures. The mating of the adult insects occurred mostly between 09:00 and 10:00, and 13:00 and 14:00. The number of eggs laid was the highest at 30℃ (20.2±1.5 eggs) and the lowest at 33℃ (21.8±2.2 eggs). The results showed that the temperature of 30℃ is the most suitable temperature for rearing *Locusta migratoria*.
The Pollination Effect of Insect Pollinators and Hand Pollination in the Asian Pear (*Pyrus pyrifolia* Nakai cv. Niitaka)

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We compared the fruit set and the quality of the Asian pear (*Pyrus pyrifolia* Nakai cv. Niitaka) among flowers pollinated by insect pollinators such as the honeybee (*Apis mellifera*) and bumblebee (*Bombus terrestris*) and pollinated artificially. The hand pollination rate was 1.3 times higher than bumblebee and 1.9 times higher than the honeybee pollination rate. Moreover, the artificially pollinated flowers produced fruit that was 5 to 10% higher in weight, 2 to 3% larger in size, and had a higher fruit shape index (L/D) than pollinated by the insect pollinators. On economic analysis, net profit from insect pollinator was 93.5 to 97.1% of net profit from hand pollination. Therefore, artificial pollination is more efficient than insect pollination in 'Niitaka' pear. However, regarding fruit quality and net profit, these results suggest that bee pollinator can be an good alternative to hand pollination in pear cv. Niitaka.

Key words: honeybee, bumblebee, pollination, hand pollination, *Pyrus pyrifolia*

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Dynastid beetle (*allomyrina dichotoma*) raising on the culture medium after *Grifola frondosa* harvest

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저근 강원도에서 생산되기 시작하는 잎새버섯의 수확후배지를 활용하여 산업콘충의 한 종인 장수풍뎅이의 사육가능성을 알아보고 장수풍뎅이 사육농가의 유충먹이 구입 시 경제적 비용절감 및 버섯재배농가의 부산물활용에따른 신 소득 창출을 위하여 시험을 추진하였다.

잎새버섯 배지는 참나무 85%와 밀기울 15%의 조성으로 이루어져 장수풍뎅이의 사육에는 무리가 없어 보였으며, 실제 유충 2령충을 4개월 사육한 결과 개체중이 21.6g으로 대조배지(참나무발효톱밥) 개체중 20.2g보다 양호하였으며 폐사율도 낮게 나타났다. 유충의 가능한 사육밀도를 알아보기 위해 일반적으로 제시하는 밀도(75마리/60L)를 기준으로 0.5, 1.5배의 밀도를 사육한 결과 60L용기에 100마리 정도 사육이 가능하였다. 성충의 암수비율에 따른 산란시험에서는 암수비율 동일조건에서 산란수가 많았으며 잎새버섯 수확후배지에서보다는 참나무 발효톱밥에서 산란이 양호하였다. 또한 산란효과를 높이기 위해 시판젤리에 여러 가지 첨가제를 넣어 시험한 결과 흑설탕 첨가 음식에서 산란이 좀 더 양호한 것으로 나타났다.

검색어: 잎새버섯 수확후배지, 발효톱밥, 장수풍뎅이, 곤충사육
Effect on the colony development of earth bumblebee fed by mixed pollens from domestic and China

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Feeding effects of the honeybee pollen products from both domestic, China, Spain and mixture of different origin on the colony development of earth bumblebee, Bombus terrestris L., were surveyed to evaluate efficient nutritional resources for commercial bombiculture in Korea.

As the results, the domestic pollen was most effective to achieve high rates of oviposition (88%), colony foundation (70%), and queen production. While feeding with domestic pollens during the egg-laying period, and domestic+Chinese mixture (5:2) during the breeding period (Plot-2), it revealed high oviposition rate of 75%, colony foundation of 65%, and large numbers of adult queen production, indicating its suitability for generation subculturing. In the Plot-3, the same high oviposition rate (75%) was obtained except for feeding with the domestic+Chinese mixture (2:5) during the breeding period, which produced large number of workers.

Key word : bombiculture, colony foundation, Bombus terrestris L. honeybee pollen.

Bacillus thuringiensis based dsRNA production platform for the control of Sacbrood virus of Asian honeybee, Apis cerana

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RNA interference (RNAi) has been considered as an alternative strategy to control agricultural pest whereby double-stranded RNA triggers a potent and specific inhibition of its homologous mRNA. Since small dsRNAs are required for various RNAi applications, there is a need for cost-effective methods for producing large quantities of high-quality dsRNA. In this study, Bacillus thuringiensis (Bt) based dsRNA production platform was established under control of sporulation-dependent promoter and vp1 gene of Sacbrood virus (SBV) was introduced. The dsRNA against vp1 gene produced from the Bt suppressed the replication of SBV. In addition, the dsRNA was assembled into inulin coated-nanoparticle to increase stability of dsRNA in environment.

Key words : Bacillus thuringiensis, Double-stranded RNA, RNA interference, Sacbrood virus, Apis cerana
Evaluation of Susceptibility of Red Poultry Mite, *Dermanyssus gallinae* (Acari: Dermanyssidae) in Five Regions to 11 Acaricides

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The susceptibility of *Dermanyssus gallinae* adults, collected from poultry farms in 5 regions, to 11 acaricides was investigated. When bifenthrin and formic acid with pyridaben were diluted 100 times, bifenthrin showed 100% acaricidal activity; however, formic acid with pyridaben showed less than 20% acaricidal activity for poultry farms in 3 regions (Gyeongju, Chilgok, and Geumsan) except Yeoncheon and Anseong. Clothianidin, thiamethoxam, fenitrothion, and formic acid with pyridaben showed differences in acaricidal activity among regions. Therefore, farmers should concentrate during the selection of these acaricides. However, carbaryl, cartap hydrochloride, dichlorvos, and bifenthrin showed high activity against *D. gallinae* collected from poultry farms in five regions. To control *D. gallinae* effectively, the alternation of acaricides is necessary, and indiscriminate pesticide use should be avoided. Therefore, this study can serve as a basis for controlling *D. gallinae*.

**Key words**: *Dermanyssus gallinae*, Acaricide, Acaricidal activity, Susceptibility

Acaricidal and repellent effects of *Cnidium officinale*-derived material against *Dermanyssus gallinae* (Acari: Dermanyssidae)

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The acaricidal activity of a methanolic extract and fractions from the rhizome of *Cnidium officinale* against *Dermanyssus gallinae* adults was investigated. The *C. officinale* methanolic extract exhibited 100% acaricidal activity after 48 h of treatment at a dose of 4,000 ppm. Gas chromatography–mass spectrometry and nuclear magnetic resonance spectroscopy revealed (Z)-ligustilide as a constituent of *C. officinale*. Acaricidal activity was examined in three experimental tests (spray, fumigation and contact), with the spraying method being the most effective. The methanolic extract of *C. officinale* showed both contact and fumigant activities, though only fumigant activity was observed with (Z)-ligustilide. These results suggest that *C. officinale* derived material can be used for the development of a control agent for *D. gallinae*.

**Key words**: *Dermanyssus gallinae*, *Cnidium officinale*, (Z)-ligustilide, bitylideneptahlidge, acarcidal activity
A feeding report of artificial diets for rice grasshopper (*Oxya chinensis sinuosa*)

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비메뚜기의 인공사료 개발을 위하여 일본의 Konno식 먹이를 대조구로 하고, 28개의 배합비율별 인공사료를 제작하여 급식시험을 하였다. 시험결과, Konno식 보다 6주 후 1마리당 체중은 22개 처리에서 높았고 우화성공율은 23개 처리에서 높았다. 폐사율은 부화입식 후 45일까지 Konno식 대비 24개 처리에서 높았다. 1마리당 체중, 우화성공율, 폐사율을 종합해 볼 때 탄수화물원으로는 옥수수 건조잎 분말 또는 통밀가루와 단백질원으로는 2-5%의 탈지대두분 또는 어분의 배합비율이 비메뚜기의 인공사료로서 가능성이 높았다.

검색어: 비메뚜기, 인공사료, 체중, 우화, 폐사율

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The storage characteristics of the larvae of *Protaetia brevitarsis* (Coleoptera: Cetoniidae)

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본 연구는 흰점박이꽃무지의 안정적인 생산과 저장법 확립을 위해 수행되었다. 이를 위해 일정 기간과 온도 조건에서 흰점박이꽃무지 유충의 저장 특성을 조사하였다. 저장 시험에 사용된 유충의 평균무게는 2.1g인 개체를 사용하여 다양한 온도조건(5°C, 10°C, 15°C, 20°C, 및 25°C)에서 일정한 용기에 각각 400마리씩 넣은 후 15주간 저장처리하였다. 조사결과 각 처리구별로 초기 저장 무게에 비해 각각 47.4%, 59.4%, 65.8%, 62.6%, 및 92.8%로 변화하였으며, 생존율은 82.8%, 94.3%, 94.8%, 91.3%, 및 94.6% 이었다. 노숙된 3령 유충(개체평균 무게 2.5g)과 성장 중인 유충(개체평균무게1.8g)을 각각 500개체씩 넣은 후 10°C에서 5개월 저장 후 체중변화와 생존율을 측정한 결과 체중은 각각 86.3%, 75.2%, 생존율은 94.6%, 96.2%이었다. 저온저장시 성장 중인 유충에 비해 노숙된 유충의 체중감소율이 적게 나타났다.

검색어: 흰점박이꽃무지, 유충, 저장특성, 체중변화
Levels and patterns of PCDD/Fs in invasive alien species, *Vespa velutina nigrithorax* (Hymenoptera: Vespidae)

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다이옥신류(Polychlorinated dibenzo-p-dioxins and furans: PCDD/Fs)는 화학적으로 매우 안정화 되어 있으며 난분해성 이자 강한 독성을 가지고 있다. 특히 환경 매체의 오염을 통해 생태계 내 생물의 생체에 종종 축적된다. 외래종 등검은말벌은 2003년 국내 침입 후 전국적으로 확산되었으며, 최근 말벌(집)을 민간요법으로 식음하는 사례가 늘면서 이로 인한 오염물질 노출 가능성이 높아지고 있다. 본 연구에서는 도시 및 산림지역에서 말벌(집)을 채집한 후 비의도적 잔류성유기오염물질 공정시험방법에 따라 전처리 후 가스크로마토그래프/고분해능질량분석기(GC/HRMS)를 이용하여 다이옥신류의 농도수준과 경향을 확인하였다. 농도는 WHO에서 제시한 2015 독성등가계수를 이용하여 TEQ농도(pg-TEQ/g)로 환산하였다. 그 결과, OCDD 등 일부 다이옥신 물질이 검출되었으나, 인체의 유해성은 낮은 것으로 보인다. 그러나 다양한 지역에서의 등검은말벌 체취 및 분석, 위해성평가 등 추가연구가 필요하다.

Larval growth of edible insects reared on various diets with different animal feeds

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Insects have been proposed as an alternative protein source that may contribute to global demands for food protein. As rising interest in edible insects, it is needed to develop the rearing techniques and nutritious feed sources for mass production. Diet mixing is believed to be advantageous for performance-related factors of edible insects such as survival and growth. In the current study, the effects of diet mixtures with wheat bran, dog feed, and pig feed were investigated on the growth performance of edible chafers, *Protaetia brevitarsis* and *Allomyrina dichotoma*. When fermented sawdust with adding 30% wheat bran was fed, larval survival rate and growth rate of both insects were significantly lower than those of the control. Fermented sawdust with high density of wheat bran was inappropriate for these insects. On the other hand, when fed with 2.5% dog feed and 2.5% pig feed, the survival rate and growth rate of the larvae were higher than those of the control. In addition, the larval period of both was shorter than that of the control by 40 days or more. Therefore, it was considered that animal feeds can be used as feed sources for those edible insects.

Key words: *Allomyrina dichotoma*, animal feed, edible insect, growth, *Protaetia brevitarsis*
Inhibition of *Metarhizium anisopliae* infection of *Protaetia brevitarsis seluensis* larvae using several effective microorganism

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Mass breeding of *Protaetia brevitarsis seluensis* results in the entomopathogenic fungal infection, usually *Metarhizium anisopliae*. A mixture of microorganisms (*Bacillus subtilis*, *Lactobacillus plantarum*, and *Saccharomyces cerevisiae*) delayed fungal infection by *M. anisopliae*, which infected fewer *P. b. seluensis* when the microorganism mixture was added to sawdust as feed for *P. b. seluensis* for 30d, their mortality rate was approximately 35% less than that of the control group, which was fed sawdust without the EM. In addition, the growth of *M. anisopliae* on agar media spread with each bacterium as inhibited by up to 80%.

Key words: *Protaetia brevitarsis seluensis*, *Metarhizium anisopliae*, entomopathogenic fungi, EM

Breeding density and spawning place for annual production of *Locusta migratoria*

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풀무치(*Locusta migratoria*)는 메뚜기과에 속하는 곤충으로 70% 이상의 단백질을 함유하고 있어 식사료용 곤충으로 이용 가능성이 높다. 그러나 풀무치의 대량생산을 위한 연중사육 관련 연구는 미흡하여 사육방법 정립, 먹이원 선발 등이 필요하다. 본 연구에서는 풀무치의 연중사육을 위한 방법으로 사육밀도에 따른 생육 특성과 최적 산란처를 찾기 위해 상토, 오아시스 등을 이용하여 산란 특성을 조사하였다. 풀무치의 생육 온도는 28℃, 습도는 65% 내외로 유지하고 처리구별 생존율, 용적습수, 크기, 무게 등을 측정하였다. 사육밀도별 약충 기간은 32일 소요되었고, 생존율은 82-90 %였으며, 성충 기간은 110-120일 소요되었다. 산란처별 난괴 길이는 33-49mm였으며, 부화 후 생존율은 72-82%였다.

검색어: 풀무치, 사육 밀도, 산란처, 생육 특성
Efficacy Test of New Attractant for the Yellow-legged Hornet, *Vespa velutina* (Hymenoptera: Vespidae)

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The yellow-legged hornet, *Vespa velutina*, has recently spread to many countries in the world, causing severe economic losses in various industries, especially honey bee production. To control the hornet, various control methods have been studied, and among these, attractants have been the subject of extensive research. Therefore, we analyzed the efficiency of the attractant developed by Damokecotech. Using two existing attractants and one newly developed attractant, we captured hornets in two locations during the period from September to November 2016. The results showed that the newly developed attractant was statistically significantly more effective than the existing attractants.

Keywords: *Vespa velutina*, attractant, capture, sampling
Storage condition setting of *Gryllus bimaculatus* (Orthoptera: Gryllidae) egg

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*Gryllus bimaculatus* is one of many cricket species known as field crickets. Also known as the African or Mediterranean field cricket or as the two-spotted cricket, it can be discriminated from other Gryllus species by the two dot-like marks on the base of its wings. *G. bimaculatus* is a subtropical insect and widely distributed from Africa to south Asia. After into the country, the species are popular for use as a food source for insectivorous animals like spiders and reptiles kept as pets. In 2016, *G. bimaculatus* was approved as a general food ingredient by Korean Ministry of Food and Drug Safety. However, domestic research on *G. bimaculatus* is still in its study is beginning stages. *G. bimaculatus* is possible species to year-round rearing without storage condition but the aim of the present study prepares for in case of problems such as breeding space, labor cost etc. In the laboratory condition at 28±2℃ and 50% relative humidity under 10h light, 12h dark photoperiod, Adult crickets oviposit at soaked flower foam for 24 hours. The experiment on the hatching of the eggs showed that eggs could be stocked at 16℃ for 10 days with 7 day pre-period after laying, representing 85% hatchability.

**Key words**: *Gryllus bimaculatus*, egg, storage condition

Development of *Protaetia brevitarsis* according to the addition ratio of mulberry cake

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This study was conducted to evaluate the efficacy of mulberry cake mixed diet on larval growth of *Protaetia brevitarsis*. As a result of adding 3, 5, and 10% mulberry cake to the fermented mulberry sawdust, the development period of the *Protaetia brevitarsis* larvae was 44.9 days, 44.6 days, and 41.8 days, and the highest weight of larvae was 2.76 g, 2.80 g, and 2.89 g, respectively. As a result of adding 3, 5, and 10% mulberry cake to the fermented oak sawdust, the development period of the *Protaetia brevitarsis* larvae was 46.7 days, 41.6 days, and 41.7 days, and the highest weight of larvae was 2.65 g, 2.65 g, and 2.56 g, respectively.

**Key words**: *Protaetia brevitarsis*, Mulberry cake, Development
Verification of the effect of hotmelt adhesive used natural-friendly repellent for packaging

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The study was conducted to verify the effect of using hotmelt adhesives that are natural-friendly repellents in packaging. The research team at the Institute of Life Science and Natural Resources at Korea University, the HIPOS R&\textsuperscript{C} Research Institute, and Nongshim Co., Ltd., developed packaging materials using natural repellents and tested their effectiveness against stored product pests.

방충포장 상용화 연구를 위하여 선정된 천연기피물질을 이용한 방충포장 소재를 개발하고 이들의 저장해충에 대한 방충효과를 시험하였다. \textsuperscript{1}농심의 라면포장 박스의 접착제로 사용되는 핫멜트에 0\% 2\%의 기피물질을 처리하고 화랑곡나방에 대한 방충효과를 시험한 결과, 2\% 기피물질이 처리된 방충 핫멜트 처리구와 무처리구 간 화랑곡나방 개체수는 박스외부에서는 차이가 없으나(\(df=30, t=0.56, P>0.05\)), 박스의 골판지 틈새(\(df=30, t=6.78, P<0.05\))와 박스 내부(\(df=30, t=2.45, P<0.05\))에서는 처리구에서 유의하게 적게 나타났으며, 무처리구와 처리구 박스내부 전체(박스내부+골판지 틈새)와 박스 전체에서 발견된 화랑곡나방 개체수도 처리구에서 유의하게 적은 것으로 조사되었다(박스내부 전체: \(df=30, t=13.58, P<0.05\), 박스 전체: \(df=30, t=13.60, P<0.05\)). 화랑곡나방 유충이 발견된 위치는 무처리구와 처리구 모두에서 박스외부가 가장 적었으며, 박스내부와 골판지 틈새의 순으로 조사되었으며 전체적으로 처리구에서 유의하게 적게 발견되었다.

検索어: 해충기피물질, 방충포장, 핫멜트, 화랑곡나방

Dose response assessment of ethyl formate (Vapormate\textsuperscript{®}) on insect pests of archives and museum

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Ethyl formate (Vapormate\textsuperscript{®}) is a non-toxic fumigant that is being considered as a replacement for methyl bromide (MB) and Ethylene Oxide (EO), which are highly toxic and have been regulated due to their ozone-depleting properties. The study aimed to assess the dose response of ethyl formate (Vapormate\textsuperscript{®}) on insect pests in archives and museums.

公시충은 광한농 작물보호연구센터 곤충사육실에서 누대사육중인 개체를 사용하였으며, 데시게이터(6.9L)에 농도별로 24시간동안 밀폐 환증처리하여 약효를 조사하였다. 통계분석은 Probit analysis 통해 \(L(Ct)\) (Lethal Concentration x Time, g $\cdot$ h $\cdot$ m$^{-3}$)값을 산출하였다. 실험결과 \(L(Ct)_{50}\) 및 \(L(Ct)_{99}\) 값은 독일바퀴의 경우 48.38 및 346.34 g $\cdot$ h $\cdot$ m$^{-3}$였으며, 화랑곡나방의 경우 14.91 및 660.94 g $\cdot$ h $\cdot$ m$^{-3}$로 나타났다. 모든 방제가 가능한 \(L(Ct)_{99}\) 값은 660.94 g $\cdot$ h $\cdot$ m$^{-3}$으로 이는 에틸포메이트 28.2 g/m$^3$(베이퍼메이트\textsuperscript{®} 170 g/m$^3$)를 24시간 처리시 완전 방제가 가능할 것으로 판단된다.

検索어: 에틸포메이트, 독일바퀴, 화랑곡나방, 베이퍼메이트
Effect of Temperature on the Development and Oviposition of Brassica leaf beetle, *Phaedon brassicae* Baly (Coleoptera: Chrysomelidae)

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The development and oviposition of *Phaedon brassicae* were studied under different temperatures. The results showed that the larval development time was significantly influenced by temperature. The authors also discussed the impact of temperature on the oviposition behavior of the beetle. The study provides valuable insights into the life cycle of *Phaedon brassicae* under varying environmental conditions.