2022 Spring International Conference of KSAE

Acclimatization to environmental change

28(Thu)-29(Fri) April 2022

SONO Belle Byeonsan, Korea

Organized by (사)한국응용곤충학회 Korean Society of Applied Entomology

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이 발표논문집은 농림식품기술기획평가원 지원을 받아 발간되었음.
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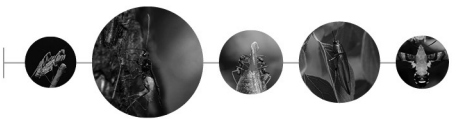


개회사

한국응용곤충학회 회원 여러분! 오늘 같은 화창한 봄날에 아름다운 격포에서 여러분을 다시 뵙게 되어 반갑습니다. 이제 방역지침이 다소 완화되어 지난 학회 때보다는 좀 자유로운 행사를 기대하지만 마지막까지 긴장의 끈을 놓지 말아야할 것 같습니다.

이번 춘계학회에서는 'Acclimatization to environmental change'를 슬로건으로 정했습니다. 환경변화에 따른 곤충학 내의 현안을 고찰할 수 있는 다양한 심포지엄을 통해 많은 정보와 의견 교환이 이루어지기를 희망합니다. 이번 심포지엄을 준비하고 진행해주신 조직위원님들과 발표자분들께 감사드립니다. 이번 학회에서는 프랑스 국립농업식품환경연구소 남기웅 박사님께서 열대거세미 관련 기조강연을 내일 해주실 예정이고, 한국곤충학상 특별강연, 심포지움 27편, 소모임 3편 신진박사 학위자 8편, 학생 40편을 비롯한 총 80편의 구두발표와 211편의 포스터발표가 오늘과 내일에 걸쳐 진행이 되니 많은 관심과 참여 부탁드립니다.

조금 전에는 제 8회 한국곤충학상 수상자로 선정되신 충북대 김길하 교수님의 특강이 있었습니다. 다시 한번 축하드립니다.

지난번에 공지 드렸던 대로, 이번 춘계에는 저희 학회의 창립 60주년 기념 국제학술행사로 진행하려 했었으나 당시 코비드 환자가 폭증되는 상황에서 부득이하게 다음 추계학회로 미뤄지게 된 점 회원 여러분의 많은 양해 부탁드립니다. 다행히 이제는 코비드 확산의 정점이 지난 듯 하고 어느 정도 집단면역이 형성된 듯하여 추계 때는 좀 더 많은 분이 참석할 수 있는 자유로운 행사가 가능할 것으로 예상합니다. 준비해주신 이경열 행사준비위원장님과 준비위원 여러분 그리고 박종균 차기 회장님을 비롯한 회장단 여러분께 아낌없는 지지와 성원을 부탁드리겠습니다.

그리고 전임 김길하 회장님을 비롯한 편찬위에서 추진해왔던 한국곤충명집 발간이 드디어 결실을 보게 됐습니다. 그간 수고해주신 100여분 가까운 집필진 여러분과 발간을 주도해주신 박종균 교수님께 감사드립니다. 우리 학회의 소중한 자산이자 곤충을 연구하는 모든 곤충학자에게 유용한 자료가 될 것으로 확신합니다.

이번 학회에서는 거리두기는 다소 완화됐지만 실내 마스크착용, 취식금지 등 아직 여러 면에서 불편한 점들이 남아있습니다. 그럼에도 불구하고 모처럼 회원 여러분들의 소속감을 확인할 수 있는 학술교류와 친목교제의 장이 되길 기대합니다. 아울러 회원 여러분들과 가족의 건강과 무궁한 발전을 기원하겠습니다.

감사합니다.

2022년 4월 28일

사단법인 한국응용곤충학회

32대 회장 **이 시 혁**

Program

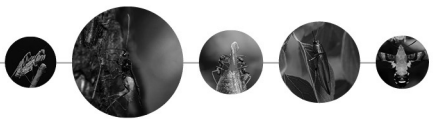
■ 2022 Spring International Conference of Korean Society of Applied Entomology ■

28 April (Thu)

Time	Contents				Room
12:00~	Registration				Desk (B1)
	Oral of Graduate School Students (Post Doctors)				
13:00~15:40	Post Doctors Grand ballroom (B1)	Taxonomy / Phylogeny Rose Ⅰ (1F)	Physiology / Molecular Biology Rose Ⅱ (1F)	Ecology Rose Ⅲ (1F)	Pest Control Rose Ⅴ (1F)
15:40~15:50	Coffee Break				
15:50~16:50	**Poster Presentation**				Emerald Ⅲ
16:50~17:00	Coffee Break				
17:00~17:40	**Korean Entomologist Award Ceremony & Special Lecture of the Winner**				Grand ballroom (B1)
17:40~18:00	**Regular General Meeting**				
18:00~18:30	**Presidential Farewell & Inaugural Ceremony for KSAE**				
18:30 ~	**Banquet**				Grand ballroom (B1)
	Small Group Meeting				
19:30~20:30	Academic Committee Meeting		Ki-Jeong Hong (Sunchon Nat'l Univ.) DongWoon Lee (Kyungpook Nat'l Univ.)		Rose Ⅰ (1F)
	Research Meeting for Welsh Onion Insect Pests		Yonggyun Kim (Andong Nat'l Univ.)		Rose Ⅱ (1F)

29 April (Fri)

Time	Contents		Room
	Symposium		
09:00~11:30	Ecological Risk Assessment of Neonicotinoids in Asia Zoom : ID 862 9799 6173 PW 318380	Chuleui Jung (Andong Nat'l Univ.)	Grand ballroom (B1)
	Challenges and Tasks for Insect Pest Management	Sora Kim (Jeonbuk Nat'l Univ.)	Rose Ⅰ (1F)
	Thrips IPM in Hot Pepper	Yonggyun Kim (Andong Nat'l Univ.)	Rose Ⅱ (1F)
	Biological Control in Practice	Yong-Seok Choi (CNARES)	Rose Ⅲ (1F)
	Industrial Pest Management : Nematode	Jae Su Kim (Jeonbuk Nat'l Univ.)	Rose Ⅴ (1F)
11:30~11:40	COFFEE BREAK		
	Plenary Lectures		
11:40~12:20	The evolution of detoxification genes with an extreme polyphagy in the pest fall armyworm	Ki Woong Nam (INRAE)	Grand ballroom (B1)
12:20 ~	Student Competition Awards and Closing Ceremony		Grand ballroom (B1)



Contents

Special Lecture

Plenary Lecture

Symposium

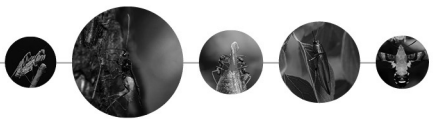
SI. Ecological Risk Assessment of Neonicotinoids in Asia

S2. Challenges and Tasks for Insect Pest Management

4. 29. Fri | Rose I (1F) | **Organizer :** Sora Kim (Jeonbuk National University)

S3. Thrips IPM in Hot Pepper

4. 29. Fri | Rose II (1F) | **Organizer :** Yonggyun Kim (Andong National University)



S4. Biological Control in Practice

4. 29. Fri	Rose III (1F)	**Organizer :** Yong-Seok Choi (Chungnam Agricultural Research & Extension Services)

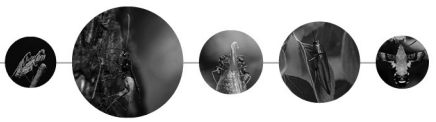
S5. Industrial Pest Management : Nematode

4. 29. Fri	Rose V (1F)	**Organizer :** Jae Su Kim (Jeonbuk National University)

Oral Presentation

1. Post Doctors

4. 28. Thu | Grand ballroom (B1) | **Moderator :** Kyeong-Yeoll Lee (Kyungpook National University), Iksoo Kim (Chonnam National University)

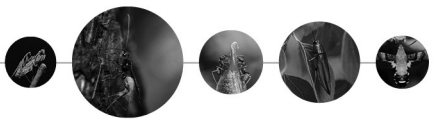


2. Taxonomy / Phylogeny

4. 28. Thu	Rose I (1F)	**Moderator :** Jongok Lim (Wonkwang University), Sora Kim (Jeonbuk National University)

3. Physiology / Molecular Biology

4. 28. Thu	Rose II (1F)	**Moderator :** June-Sun Yoon (Jeonbuk National University), Kyungjae Andrew Yoon (Seoul National University)

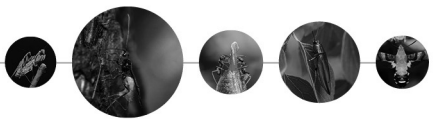


4. Ecology

4. 28. Thu | Rose III (1F) | **Moderator :** Ikju Park (Kyungpook National University), Changku Kang (Seoul National University)

5. Pest Control

4. 28. Thu	Rose V (1F)	**Moderator :** DongWoon Lee (Kyungpook National University), Donghun Kim (Kyungpook National University)



Small Group Meeting

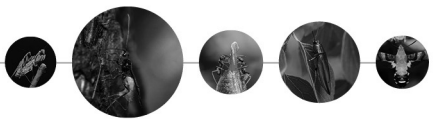
Research Meeting for Welsh Onion Insect Pests

4. 28. Thu | Rose II (1F) | **Moderator :** Yonggyun Kim (Andong National University)

Poster Presentation

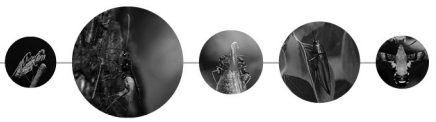
1. Taxonomy & Phylogeny

Moderator : Heungsik Lee (Animal and Plant Quarantine Agency)



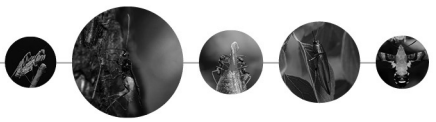
Moderator : Jung Hoon Hwang (Animal and Plant Quarantine Agency)

Moderator : Sora Kim (Jeonbuk National University)



Moderator : Jongok Lim (Wonkwang University)

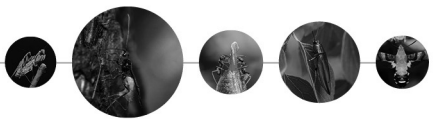
Moderator : Il-Kwon Park (Seoul National University)



Moderator : Geonho Cho (Sunchon National University)

2. Physiology

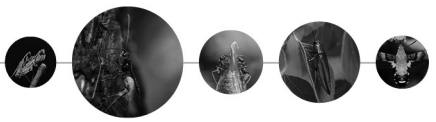
Moderator : Junheon Kim (National Institute of Forest Science)



3. Molecular Biology

Moderator : Young Ho Kim (Kyungpook National University)

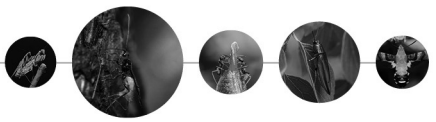
Moderator : Hyun-Na Koo (Chungbuk National University)



4. Ecology

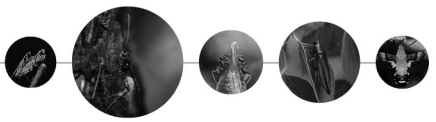
Moderator : Jong-Kook Jung (Kangwon National University)

Moderator : Ikju Park (Kyungpook National University)



Moderator : Doo-Hyung Lee (Gachon University)

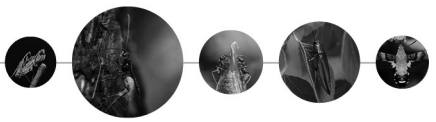
Moderator : Jung-Joon Park (Gyeongsang National University)



Moderator : Tae Young Shin (Jeonbuk National University)

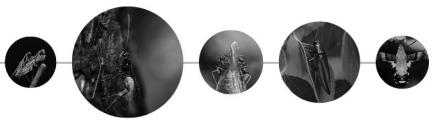
5. Pest Control

Moderator : Young Su Lee (Gyeonggi Agricultural Research and Extension Services)



Moderator : Hwa Yeun Nam (Kangwon National University)

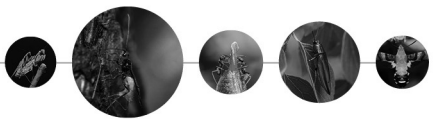
Moderator : Se Jin Lee (Sunchon National University)



6. Industrial Entomology

Moderator : Kwang Sik Lee (Dong-A University)

Moderator : Bo Yeon Kim (Dong-A University)



7. Other

Moderator : Bo Yoon Seo (National Institute of Crop Science)

Special Lecture

Study of Control Against Insect Pests (1983～Present)

Gil-Hah Kim
Department of Plant Medicine, Chungbuk National University, Korea

존경하는 한국응용곤충학회 회원 여러분!

2022년도 한국곤충학상 수상자로 선정되어 매우 영광스럽게 생각하며 힘든 시기에도 불구하고 오늘 학회에 참석해주셔서 감사합니다. 저는 1983년 대학원에 진학하여 응용곤충학 연구를 시작하게 되었고 지금까지 진행해 오고 있습니다. 그동안의 연구내용에 대해 간략하게 설명해드리겠습니다.

연구 분야는 주로 해충을 방제하기 위한 기법으로 크게 3가지로 나눌 수 있다. 첫째, 국내 해충 발생상황을 파악하여 주요 해충종별, 약제계통별 모니터링 및 약제저항성 기작규명과 해충관리 둘째, 훈증제를 이용한 농산물 검역해충 소독기술 개발 셋째, 이온화에너지(전자빔, X-선, γ-선) 이용 곤충 불임화 기술(SIT)에 의한 해충방제로써 농업현장의 문제를 해결하기 위해 꾸준히 노력해 왔다. 또한 농학 전공 교수로서 농민과 함께 지역농업의 생산성 활성을 위해 농림수산식품부지정 포도연구사업단장(2005～2010), 충북복숭아산학협력단장(2012～2014), 그리고 충북포도·와인산학협력단장(2015년～2020)을 맡아 우수 농산물 생산, 육성과 브랜드 개발에 전력을 다해왔다.

오늘 이 영광스런 자리에 설 수 있었던 것은 저 혼자만의 힘이 아니라 저를 지도해주신 스승님, 그리고 충북대학교 식물의학과 곤충독성학연구실 제자들의 노력이 있었기에 가능했다고 생각하며 이 자리를 빌려 감사드린다.

검색어: 해충, 약제 저항성, 훈증제, 이온화에너지, 방제

Plenary Lecture

The evolution of detoxification genes with an extreme polyphagy in the pest fall armyworm

Ki Woong Nam
University of Montpellier, Montpellier, France INRAE, Montpellier, France

Phytophagous insects feed on plants by overcoming plant defense toxins. Arms races drive rapid evolutionary changes in the composition of plant toxins and the repertories of detoxifications genes. These detoxification genes also play a key role in field-evolved insecticide resistance. The fall armyworm (*Spodoptera frugiperda*) is a major pest insect against major crops, including corns and rice. This species exhibits extremely polyphagy by eating more than 300 plant species. In addition, field-evolved insecticide resistance is commonly observed, especially from Puerto Rico and China where insecticides are heavily sprayed. The comparative genomics analysis reveals that the fall armyworm has higher numbers of detoxification genes, including P450 genes, than monophagous lepidopteran species. Population genomics analysis shows that an insecticide-resistant population from Puerto Rico has an increased number of P450 genes than a susceptible population. Bioassay experiments demonstrated that P450 genes play a key role in the insecticide-resistance. Interestingly, the invasion of fall armyworms from the New World to the Old World is accompanied by the increased number of P450 genes in invasive populations. We speculate this increase is associated with prevalent insecticide resistance in Chinese populations. These results show that detoxification genes are under macro and micro evolution that are driven by plants and humans, respectively.

Key words: Biological invasion, Fall armyworn, Insecticide resistance, P450, *Spodoptera frugiperda*

Symposium

S1-1

Neonicotinoids as drivers of the global decline of the entomofauna

Dr Francisco Sánchez-Bayo
Honorary Associate at the University of Sydney

A review of historical reports from across the globe has shown that worldwide biodiversity of insects is at peril. Dramatic rates of decline affect 37% of the world's insect species, with most of them being threatened to become extinct over the next few decades. A more recent UN report by the IPBES also found that 25% of the world species of animals and plants (about 1 million species) are at risk of extinction in the coming decades. In terrestrial ecosystems, butterflies, moths, bees and dung beetles appear to be the insect groups most affected, whereas the four major groups of aquatic insects (dragonflies, stoneflies, caddisflies and mayflies) have already lost a considerable proportion of species in most ecosystems. In addition, insect biomass has decreased at a rate of over 2% annually in the past four decades. While it is recognized that the causes of such declines are multifactorial, pollution by agricultural chemicals is clearly involved in the disappearance of insects from both terrestrial and aquatic ecosystems. Among the many agricultural chemicals that contaminate the environment, neonicotinoids are thought to be one of the main drivers of insect declines due to their ubiquitous presence in soil, flowers and surface waters, their persistence in these media and particularly their high chronic and latent toxicity to insects. The ecological implications of such declines and the priority actions regarding neonicotinoid usage will be discussed.

S1-2

Risk assessment and regulation of neonicotinoid insecticides(NNIs)

Su-Myeong Hong, Kyongmi Chon and Jin-A Oh
Department of Agro-food Safety and Crop Protection
National Institute of Agricultural Sciences, Rural Development Administration

1980년대에 개발되어 인축 안전성과 뛰어난 살충효과로 채소류와 과실류에 발생하는 진딧물과 나방류 방제에 주로 사용한 네오니코티노이드계 살충제는 imidacloprid, clothianidin, thiamethoxam 등 3종의 살충제가유럽연합에서 2018년 벌에 대한 위해성이 인정되어 실외사용이 금지되고 시설하우스 재배 작물에 대해서만 파종부터 수확기까지 제한적 사용만 허락되었다. 이를 계기로 미국 환경청(US EPA) 및 유럽식품의약품안전청(EFSA)에서는 농약에 의한 벌의 위해 평가기법을 발전시켜 적용하고 있다. 미국과 유럽연합에서 진행하고 있는 3단계 평가시스템(screening, semi-field, field)의 개선해야 할 점을 살펴보면 급성 접촉 노출 위주의 평가에서 만성 섭식 노출평가법 도입이 시급하고 Tier 1단계에서 봉군 영향 유무를 알 수 있는 스크리닝 기법 개발 및 적용도 필요하다. 우리나라 농약 관리에서 적용하고 있는 벌에 대한 농약 위해성 평가 기준도 미국과 유럽의 선진국 평가체계에 부합되기 위해 개선하고 있다. 미국 환경청에서도 벌의 위해성은 농약을 포함한 여러 요인들에 의해 질병에 취약하게 됨에 따라 봉군세력이 감소하고 나아가 봉군 붕괴현상이 발생한다고 보고하고 있으므로 체계적이고 정밀한 과학적 근거를 바탕으로 농약에 의한 벌의 위해 평가 기준과 농약 관리 정책을 개선하여야 한다.

검색어: 네오니코티노이드계, 살충제, 위해 평가, 농약 관리, 벌 위해성

S1-3

Biodiversity-driven pest management: a powerful alternative to pesticide-based approaches

Kris A.G. Wyckhuys[1,2,3,4]

[1]State Key Laboratory for Biology of Plant Diseases and Insect Pests, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing, China

[2]University of Queensland, Brisbane, Australia

[3]Fujian Agriculture and Forestry University, Fuzhou, China

[4]Chrysalis Consulting, Hanoi, Vietnam

Worldwide, insects are undergoing a precipitous decline. Their dwindling population numbers can be ascribed to habitat loss, agrochemical pollution, invasive species and climate change. Insects however are of vital importance to humanity as they ensure the delivery of multiple ecosystem services e.g., biological pest control. In this presentation, we show how (insect) biodiversity can effectively be harnessed to provide more sustainable forms of pest management and to steadily transition away from pesticide-centered approaches. Drawing on a case study from subtropical Asia, we illustrate how biological control can provide environmentally friendly and durable control of herbivorous pests over a continental scale. In 2008, the mealybug *Phenacoccus manihoti* (Homoptera: Pseudococcidae) invaded Southeast Asia, where it caused major losses in cassava and triggered 2- to 3-fold surges in the price of cassava starch – a globally-traded commodity. To mitigate *P. manihoti* outbreaks, systemic insecticides were promoted and the host-specific parasitoid *Anagyrus lopezi* (Hymenoptera: Encyrtidae) was introduced. Through observational studies, region-wide population surveys and manipulative assays, we demonstrate how *A. lopezi* established in multiple Asian countries and provides a pesticide-free of suppression of *P. manihoti*. We equally show how mealybug biological control has stabilized the inter-country trade of cassava-derived commodities and reduced price volatility in global futures markets. Lastly, we illuminate how biological control helped to slow the expansion of the agricultural frontier, easing pressures on tropical forests. Our research provides an eye-opening account of how insect biodiversity underpins the overall resilience of tropical agro-ecosystems and offers powerful solutions for (invasive) pest issues. Our work underlines the immense potential of ecologically based tactics to safeguard agri-food production across the globe, and to deliver multiple (often un-anticipated) societal benefits at large spatial scales.

S1-4

Environmental risk assessment of neonicotinoids for Asian honey bee and simultaneous analysis of pesticide residues in apiculture samples

Yongho Shin[1], So-Hee Kim[1], Woo-Seok Ahn[1], Mun-Ju Jeong[1] and Jeong-Han Kim[2]
[1]Department of Applied Biology, Dong-A University
[2]Department of Agricultural Biotechnology, Seoul National University

2006년부터 미국, 유럽 등지에서 보고되고 있는 꿀벌군집붕괴현상(colony collapse disorder; CCD)의 원인 중 하나로 일부 neonicotinoid계 살충제가 지목되고 있으며, 유럽연합에서는 2018년 말부터 꿀벌 위해성이 확인된 neonicotinoid계 농약 중 3종의 옥외 사용을 금지한 바 있다. 해당 농약의 꿀벌 급성독성수치는 0.004~0.005 μg/bee로 EPA 기준치(11 μg/bee) 대비 독성이 매우 크며, 한국, 중국, 동남아시아 등에서 보고된 바에 따르면, neonicotinoid계 농약이 꿀벌의 후각 능력 상실 등 만성적인 영향을 미치는 것으로 나타났다. Neonicotinoid에 대한 꿀벌의 환경 위해성 평가를 위해 chromatography, mass spectrometry 등을 활용하여 양봉시료 중 농약 동시 분석법을 개발하고 해당 시료에 대한 지속적인 모니터링이 필요할 것으로 사료된다.

검색어: honey bee, neonicotinoid, colony collapse disorder, environmental risk assessment, pesticide analysis

S1-5

A systematic review to assess the effect of neonicotinoids on pollinators in Asia

Sampat Ghosh[1], Tekalign Begna[2], Leknath Kafle[3] and Chuleui Jung[1,2]
[1]Agriculture Science and Technology Research Institute, Andong National University, Korea
[2]Department of Plant Medical, Andong National University, Korea
[3]Department of Tropical Agriculture and International Cooperation, National Pingtung University of Science and Technology, Taiwan

Bees are important pollinators for about 70% of the crops we cultivated, accounting for 30% of the total food production of the world. Neonicotinoids, a group of synthetic insecticide, exposure appears to have negative effects on honey bee health and resulting colony loss in several regions of the world, especially in Europe and North America during the last two decades. In order to understand the current scenario on the effect of neonicotinoids on pollinators in Asia and Oceania, we currently carrying out a systematic review based on the available scientific publications and datasets from the region. Our analysis, based on the available dataset, demonstrates two different trends in Asian countries. Countries like China, Korea, India, Iran, Israel, Myanmar, Pakistan, and Vietnam showed an increasing trend in the number of honey bee hives during the last three decades. In contrast, Australia, Japan, Mongolia, Taiwan, and Uzbekistan followed either decreasing trend or no change was found. This present review represents the diverse situation of Asian honey bees in relation to population dynamics and possible neonicotinoid exposure, neonicotinoid toxicity to honey bees and other pollinators including bumble bees and solitary bees (LD_{50} and LC_{50}), geographical and environmental condition, and pattern of insecticide usage.

Key words: Honey bee, ecotoxicity, hive products, insecticide, LD_{50}, LC_{50}

S1-6

Impact of neonicotinoid insecticides on target pests and natural enemies

Young Su Lee, So-Hee Kim, Jong Yoon Choi, Hyun Ju Lee, Sang-Woo Lee and Jung-Su Park
Gyeonggi Agricultural Research and Extension Services, Hwaseong 18388, Korea

The neonicotinoid insecticides were developed in the early 1990s and are being used for various insect pests control in more than 120 countries. As this insecticide has been widely used, the resistance of insect pests such as *Bemisia tabaci*, *Myzus persicae*, *Nilaparvata lugens,* etc. has been reported since 1996, and the toxicity against natural enemies, which are the precious factors of integrated pest control are also appearing as side effects. In this study, we examined the side effects of neonicotinoid insecticide and suggested some ways to solve the problem.

Key words: Insecticide, resistance, toxicity, natural enemy, neonicotinoid

S1-7

Schematic presentation of ecological risk assessment of neonicotinoid insecticides in Asia

Chuleui Jung[1,2], Sampat Ghosh[2] and Minjung Kim[2]
[1]Plant medicals, Andong National University, Korea 36729
[2]Agricultural ST research institute, Andong National University, Korea 36729

Neonicotinoid insecticide is a relatively new class of insecticides registered for multiple uses of seed treatments, soil drenches and foliar-sprays. Active ingredients are systemic compounds effective to kill sucking or chewing insects. However these ingredients are persistent in soils and highly soluble in water, possibly causing broader contamination in environment. They are now dominating the insecticide market worldwide and also in Asia. Recent decline of honey bee provoked attention for these chemicals for revisitation of environmental risk assessment not only on pollinators but also on other beneficial insects and organisms including human. As since most of the risk assessment were conducted in European and American situation, in depth assessment in Asian agricultural environment is necessitated because of the different ecological, environmental and agricultural setting. Here we provide the schematic frames for this risk assessment of neonicotinoid insecticides in Asia.

Key words: Insecticide, environment, water contamination, pollinator, honeybee, agriculture

S2-1

Necessity for build of molecular data on insect pests and future convergence research: modern taxonomic approach to insect pests

Sora Kim
Department of Plant Protection & Quarantine, Jeonbuk National University

Taxonomy is a very essential and highly applicable field in studying insects. The emergence of DNA barcode technology, which has been developed since the 2000s, has complemented the limitations of traditional taxonomy and laid the foundation for leading the modernization of insect taxonomy. Currently, molecular biological data contribute to the speed and accuracy of species identification in studies for insect pest control, and its application fields, such as molecular taxonomy are expanding. This study presents examples of modern taxonomy targeting insect pests and aims to open the possibility of convergence research with various fields for insect pest control in the future.

Key words: taxonomy, DNA barcoding, molecualr, insect pests

S2-2

Apparent competition on invasive and threatened thistles: its implication on classical biological control of weeds in Korea

Ikju Park
Department of Applied Biosciences, Kyungpook National University

While more than 99% of released biological control agents do not impact native plant populations, indirect non-target attacks on native plants still raise potential concerns in classical biological weed control programs. Since insects exploit signals produced from plants before landing on them for sustained feeding and oviposition, examining the signals used by insects may enhance the prediction of potential non-target attacks by both potential and released biological control agents on native plants. To investigate the foraging behavior of female weevils, volatile organic compounds (VOCs) emitted from both an invasive thistle and a native threatened thistle were examined using a dynamic headspace volatile collection system and gas chromatography-mass spectrometry. Weevils reacted to electrophysiologically active VOCs from two thistle species. In behavioral bioassays, weevils did not differ between an invasive thistle and a native threatened thistle. Thus, the abovementioned approach opens new opportunities to reduce apparent competition for invasive plant management in Korea.

Key words: Biological control, thistles, apparent competition, invasive species, *Rhynocyllus conicus*

S2-3

Evaluation of inhibitor of apoptosis genes in *Tribolium castaneum* and use it as targets for RNAi-mediated pest control

June-Sun Yoon[1], Jinmo Koo[2], Smitha George[2] and Subba R Palli[2]
[1]Department of Agricultural Convergence Technology, Jeonbuk National University, Jeonju 54596, Republic of Korea
[2]Department of Entomology, University of Kentucky, Lexington, Kentucky

Apoptosis is the process of programmed cell death. Inhibitor of apoptosis (IAP), as its name represents, is a negative regulator of apoptosis that inhibits the apoptosis. Some of IAP genes literally involved in apoptosis pathway and some of them are not. Even though *Tribolium castaneum* is the one of the most well-studied insect model, there is no such study for IAP gene group. Therefore, we compared the IAP gene annotations between NCBI (https://www.ncbi.nlm.nih.gov/) and UniProt (https://www.uniprot.org/) databases. Using RNAi as a functional study tool, we found the function of each IAP gene via *in vitro* (TcA cell) and *in vivo* assay. The *in vitro* results indicated that knockdown of IAP1 gene induced high level of cell apoptosis and IAP5 showed a decreased cell proliferation. According to the *in vivo* assay, more than 95% mortality was shown in IAP1 dsRNA(double-stranded RNA) treatment and 100% mortality was shown in IAP5 dsRNA treatment. This study implies that iap1 and iap5 can be developed as targets for RNAi-based insect pest control.

Key words: *Tribolium castaneumis*, Apoptosis, UniProt , Knockdown, IAP5

S2-4

Outbreak of forest insect pests in Korea: recent cases and future challenge for entomologist

Jong-Kook Jung
Department of Forest Environment Protection, Kangwon National University

In recent, several forest insect pests, such as gypsy moth (*Lymantria dispar*) from 2019 to 2021, stick insect (*Ramulus mikado*) from 2020 to 2021, and others were outbreak and huge forest areas were defoliated. According to gypsy moth in 2020, a total of 6,813 ha, mainly in central area of South Korea, were defoliated, while several hectares in several mountains of Gyeonggi province were defoliated. Some other insect pests, such as pine moth (*Dendrolimus spectabilis*) and prominent moth (*Euhampsonia cristata*), were also occurred in 2021 and defoliated their host plants. These outbreaks with forest defoliation may be caused by climate changes, but we need to clarify why some insect species were severely impact on forest ecosystems.

Key words: Asian gypsy moth, Stick insect, Pine moth, Prominent moth, Forest defoliation

S2-5

Pest management using entomopathogenic fungi : current research trends

Se Jin Lee[1], Hoe Ri Kim[1] and Jae Su Kim[2]
[1]Department of Agricultural Life Science, Sunchon National University
[2]Department of Agricultural Biology, Jeonbuk National University, Korea

Climate change is one of the important global issues, that have a great impact on agriculture. According to a recent study, as global temperatures rise, insect populations will increase. The increase in their populations can directly affect the production of crops. Therefore, the role of insecticides in inhibiting the growth of insect pests is important. Synthetic pesticides have been used mainly to control pests, but the biopesticide market is growing due to ecological imbalance and other problems. Among them, microbial origin insecticides are expected to show high growth rates, as they are composed of naturally occurring viruses, fungi, or bacteria. In fact, many microbial insecticides have been developed, especially insect killing fungal insecticides with a wide control spectrum against insect pests. However, insect killing fungi, which are heavily affected by the environment such as temperature and humidity, need a new strategy method for successful pest management. Herein, we investigated the possibility of control of agricultural insect pests using insect killing fungi and examined the recent trends in fungal insecticides.

Key words: fungal insecticide, insect killing fungi, insecticide, insect pest, pest management

S3-1

Genetic lineage of *Thrips palmi* (Thysanoptera: Thripidae) and their haplotype composition in South Korea, using mitochondrial COI gene sequences

Gwan-Seok Lee[1], Bo Yoon Seo[1], In Hong Jeong[1] and Wonhoon Lee[2]
[1]Crop Protection Division, National Institute of Agricultural Sciences, RDA
[2]Department of Plant Medicine, Gyeongsang National University

The melon thrips, *Thrips palmi*, is an invasive pest that attacks many kinds of greenhouse vegetable crops in South Korea. The thrips, assumed to be native to South Asia, was first found in Jeju Island in 1993, and since then it has gradually expanded northward. Recent molecular works indicated that the species composes of two or three genetic groups worldwide. To understand the genetic structure of *T. palmi* in South Korea, we investigated genetic lineage and haplotype composition, using about 720 mitochondrial COI gene sequences (507bp), 450 newly obtained and 270 from GeneBank and BOLD. The COI gene analysis shows that single genetic group distributes in South Korea. Among 46 COI-haplotypes worldwide, 13 haplotypes are found in South Korea. In particular, only H1 haplotype is predominant and distributes nationwide.

Key words: *Thrips palmi*, genetic lineage, invasive pest, COI haplotype

S3-2

Geostatistical modeling and density estimation of *Frankliniella occidentalis* in pepper greenhouses

Jung-Joon Park[1,2], Taechul Park[1], Soeun Eom[1] and Kimoon Son[1]
[1]Department of Plant Medicine, Gyeongsang National University
[2]Institute of Agriculture and Life Science, Gyeongsang National University

Spatial density estimation for unsampled position with ordinary kriging for the western flower thrips, *Frankliniella occidentalis* in greenhouse peppers were evaluated with data from mathematical restricted variogram model parameters. Density estimation of unsampled position was evaluated with 50, 30, 20% of the independent data from another greenhouses which do not used for variogram model estimation and estimated density of the whole independent data. Interpolation mapping by 50% of independent data showed best performance. Density estimation with ordinary kriging, the relative lower value of relative nugget effect and ratio of distance between actual samples to effective range from variogram model parameters.

Key words: Variogram model, Ordinary Kriging, *Frankliniella occidentalis*, Pepper greenhouses

S3-3

Basic studies of economic injury levels and economic thresholds for *Frankliniella occidentalis* in hot pepper

Eunhye Ham[1], Hyejeong Jun[1], Yunbok Nam[1] and Yonggyun Kim[2]
[1]Institute for Bioresources, Osangkinsect Co., Ltd.
[2]Department of Plant Medicals, Andong National University

본 연구는 고추에서 꽃노랑총채벌레의 최적 방제 시기를 특정하기 위하여 수행되었다. 꽃노랑총채벌레 접종 밀도에 따른 피해엽율과 상품화율과의 상관관계 확인 및 회귀분석을 바탕으로 경제적피해수준 및 요방제 수준을 설정하였다. 꽃노랑총채벌레 누적밀도일(Cumulative Insect Days, CID)은 잎과 꽃에 대한 밀도를 대상으로 각각 분석하였다. 누적밀도일에 따른 상품화율은 통계적 유의차를 확인할 수 없었으나, 피해엽율은 선형회귀식으로 잘 표현되었다. 이 식으로부터 수량감소율 5% 수준인 9 CID가 경제적피해수준으로, 경제적피해수준의 80%가 되는 7.2 CID가 요방제수준으로 추정되었다. 이후, 현장에서의 활용성 제고를 위해 토마토반점위조바이러스 보독율과 관련한 요방제수준 설정연구를 추가로 진행할 계획이다.

검색어: 꽃노랑총채벌레, 고추, 경제적피해수준, 요방제수준, 누적밀도일

S3-4

Virome analyses from *Cnidium officinale* and *Thrips nigropilosus* in Korea

Jeong-Hun Kang[1], Myeonghwan Kwak[1], Chung Ryul Jung[2], Jung-Beom Yoon[3] and Eui-Joon Kil[1]
[1]Department of Plant Medicals, Andong National University, Andong
[2]Forest Medicinal Resources Research Center, NiFoS, Yeongju
[3]Horticultural and Herbal Crop Environment Division, NIHHS, RDA, Wanju

In Korea, *Cnidium officinale* is cultivated as a medicinal plant, mainly cultivated in the highland regions of Gangwon-do and northern Gyeongsangbuk-do. Viruses such as apple stem grooving virus (ASGV), cucumber mosaic virus (CMV), cnidium vein yellowing virus 1 (CnVYV-1), and cnidium vein yellowing virus 2 (CnVYV-2) have been identified and reported in cultivated *C. officinale*. During May and June 2021, *C. officinale* plants grown in four regions located in the eastern part of Korea and *Thrips nigropilosus* living therein were collected. Mainly samples showing vein clearing and chlorotic spots in leaves, and thrips occurring in nearby areas were also used for analysis. Total RNA was extracted and the cDNA libraries were generated. Next-generation sequencing (NGS) was performed using an Illumina Novaseq 6000 (100 bp paired-end read), and then analyzed raw read data with CLC Genomics Workbench. CnVYV-1, CnVYV-2, CMV, and ASGV previously reported in Korea were commonly identified in *C. officinale* leaf samples, and cnidium virus X was also identified in all but one region. In addition, sequences of viruses suspected to be novel viruses belonging to the *Solemoviridae* and *Betaflexiviridae* families have been additionally identified. In thrips, reads for CnVYV-1, CnVYV-2 and CMV were confirmed. Nucleic acid sequence similarity among trimmed and rearranged contig sequences identified in each region was analyzed.

Key words: Sucking pests, population fluctuations, bio rational, pest management

S3-5

RNAi of thrips PBAN to suppress aggregation pheromone biosynthesis and its application to control *Frankliniella occidentalis*

Yonggyun Kim and Falguni Khan
Department of Plant Medicals, Andong National University

Aggregation pheromone plays a crucial role in mating and host exploitation in insects. The western flower thrips, *Frankliniella occidentalis*, releases aggregation pheromone by male adults in a mixture of two terpenoids of neryl methylbutanoate and lavanduly acetate. Mating behavior occurs at daytime, suggesting a control of the pheromone biosynthesis. This study reports a novel pheromone biosynthesis activating neuropeptide (PBAN) of *F. occidentalis*. Its transcript encodes a 262 amino acid-length polypeptide, which includes diapause hormone, β-subesophageal ganglion neuropeptide, and PBAN. It was highly expressed at young male adults. Its expression pattern follows a diurnal rhythmicity. RNA interference of PBAN expression was performed by feeding gene-specific double stranded RNA. RNAi-treated males significantly lost their attractiveness to females.

Key words: *Frankliniella occidentalis*, aggregation pheromone, PBAN, RNAi

S4-1

Survey on biological control factors of Asian gypsy moth (*Lymantria dispar*) in Korea

Hwal-Su Hwang[1], Seong-Min Lee[2], Young Su Lee[3], Duck Soo Choi[4] and Kyeong-Yeoll Lee[1]
[1]Department of Applied Biosciences, Kyungpook National University
[2]Gyeongsangbuk-do Forest Research Institute, Gyeongju
[3]Gyeonggi Agricultural Research and Extension Services
[4]Jeonnam Agricultural Research and Extension Services

아시아 매미나방(*Lymantria dispar*)은 돌발 해충으로서 2019-2020년 경기도, 충청도, 경북 지역 등에서 대량 발생하여 산림뿐만 아니라 도심공원 등 큰 피해를 끼쳤지만 2021년에는 그 밀도가 현저히 감소하였다. 2021년 밀도감소 원인을 분석해 본 결과 곤충병원성곰팡이, 핵다각체병바이러스, 기생파리, 알좀벌과 같은 다양한 생물적 방제의 증가로 인하여 매미나방 발생이 억제된 것으로 판단된다. 20201년 3월 예천에서 채집한 알집을 실내에서 사육한 결과 짚시나방벼룩좀벌과 짚시알깡충좀벌의 기생율이 높았고, 유충시기에는 핵다각체병바이러스병 발생율이 80%로 나타났다. 2021년 5월에 예천지역에서 채집한 유충에서는 집시나방기생파리의 기샐율이 높았으며, 6월초에 현장조사 결과 대부분 5-6령 유충들이 핵다각체병바이러스 및 곤충병원성곰팡이에 감염되어 죽은 사체로 존재했다. 이러한 생물적 방제 인자들은 국내 매미나방 밀도 조절에 중요한 역할을 한 것으로 판단된다.

검색어: 기후변화, 돌발해충, 대발생, 매미나방, 생물적 방제, 천적

S4-2

The possibility of chinese cabbage and tobacco as a banker plant for *Orius laevigatus* and *Nesidiocoris tenuis* tobacco

Seung-HwanYun, Sang-Wook Han, Jong-In Choi, Jeong A Han and Jung-Su Park
Gyeonggi Agricultural Research and Extension Services, Hwaseong 18388, Korea

토마토 재배지에서 사용되는 천적인 미끌애꽃노린재와 담배장님노린재에 대하여 활용할 수 있는 뱅커플랜트에 대한 시험을 시설하우스에서 수행하였다. 미끌애꽃노린재를 대상으로 배추와 채송화를 처리한 뒤 미끌애꽃노린재의 밀도를 조사하였으며 배추에는 복숭아혹진딧물을 접종하여 먹이원을 공급해주었다. 배추에서 미끌애꽃노린재가 채송화 대비 서식밀도가 높게 나타나는 것을 확인하였으며 배추는 미끌애꽃노린재의 뱅커플랜트로 활용가능할 것으로 판단된다. 담배장님노린재를 대상으로 담배와 가지를 처리한 뒤 담배장님노린재의 밀도와 담배가루이 밀도를 조사하였다. 방사초기 담배에서 담배장님노린재 밀도가 높은 경향을 보였으나 가지에서는 담배장님노린재 밀도가 높게 나타나지 않았다. 추가로 담배와 가지의 담배가루이의 유인효과를 검정한 결과 두 식물 모두 토마토 대비 담배가루이에 대한 유인 효과를 가지는 것을 확인하였다. 담배는 담배장님노린재의 뱅커플랜트 및 담배가루이의 트랩식물로써 활용가능성이 높아보인다. 다만, 투입한 뱅커플랜트에서 서식하는 담배가루이 및 2차 해충에 대한 관리기술에 대한 추가적인 연구 또한 필요한 것으로 보인다.

검색어: 뱅커플랜트, 천적, 생물학적방제, 담배장님노린재, 미끌애꽃노린재

S4-3

The use of *Muscidifurax raptor* (Hymenoptera: Pteromalidae) for biological control of *Musca domestica* (Diptera: Muscidae)

Young Kyu Park
Korea Beneficial Insects Lab. co. Ltd.

집파리(*Musca domestica*)는 기계적 전파에 의해 여러 가지 질병을 전파하며 사람의 주거환경에 유입되어 불쾌감이나 혐오감을 주는 대표적인 위생해충이다. 국내 집파리의 생물적방제에 대한 연구는 1999년 국립보건원과 서울대학교의 "가축해충의 저공해성 종합적방제 체계 확립" 농림부 연구보고서에서 파리류 번데기천적 13종을 채집하여 천적의 생태 및 효과에 대하여 처음 소개하였다. 한국유용곤충연구소에서는 2002년부터 집파리번데기 기생천적 배노랑파리금좀벌(*Musckdifurax raptor*)의 대량증식시스템을 개발하였다. 그리고 천적의 효율적인 방사방법, 방사횟수 및 방사밀도 그리고 종합적 방제(Integrated Pest Management)에 대하여 연구하여 현재까지 상용화하고 있다. 2021년에 집파리번데기 기생천적은 전국의 1,000여 농가에 보급되어 생물적방제 수단으로 활용되었다. 앞으로 파리류 해충의 생물적 방제를 위한 천적곤충의 활용은 친환경적 해충방제의 수단으로서 전국 축산농가 및 매립지 등의 파리발생원에 확대되어 활용될 것으로 기대되어진다.

검색어: 배노랑파리금좀벌, 집파리, 생물적방제, 대량사육, 상용화

S4-4

Enhancement of biological control with predator's trail chemicals as a repellent

Meeja Seo
Crop Protection Division, National Institute of Agricultural Sciences, RDA

The trail chemical deposited by the convergent ladybird beetle, *Hippodamia convergens* elicited repellency of feeding and oviposition as well as reducing host acceptance of the Asian citrus psyllid, *Diaphorina citri*. Based on T-maze olfactometer and host choice experiments, we investigated the behavioral responses of *D. citri*, to the ladybeetles' trails. *D. citri* significantly avoid plants treated to the trail chemical so that the treatment caused 15 days of residual behavioral activity on *D. citri*. *D. citri* females preferred to oviposit on control flushes than those with ladybird trail extract treatments. Also, the population growth rate of the brown citrus aphid, *Toxoptera citricida* was significantly reduced on plants treated with *H. convergens* trail extract 10 and 15 days after treatment as compared with on control seedlings. Therefore, our results support potential practical application of predator's trail could be useful for behaviorally managing these phytopathogen vectors.

Key words: ladybird beetle trail, Repellency, *Diaphorina citri*, *Toxoptera citricida*

S4-5

Developmental characteristics and behavioral response of *Bemisia tabaci* (Homoptera: Aleyrodidae) on horse-weed

Yong-Seok Choi, Yoon-Sung Won, Gun-Woo Lee, In-Soo Hwang, In-Soo Hwang and Gyeong Ju Lee
Division of Eco-friendly Environment, Chungnam Agricultural Research & Extension Services, Korea

The amount of *Bemisia tabaci* adults attracted and sticked on yellow sticky traps to horse weed, thistle, red-been, cucumber and tomato in organic farming tomato greenhouse was highest on cucumber in the early days of *B. tabaci* occurring but was highest on horse-weed on the whole. The amount of them to eight species of beens was highest on Ultari-Gangnang Cong but beens was not effective trap plant to *B. tabaci.* The behavioral response of olfactory with 4-choice olfatometer shown that *B. tabaci* adults liked horse-weed better than cucumber, egg plant and tomato as the time of investigation was spent. Also The developmental period of *B. tabaci* egg and larvae was shorter in high temperature. In case of 30℃, the developmental period of egg was about 0.5 days shorter and larvae was about 1 days on horse-weed than cucumber and tomato.

Key words: *Bemisia tabaci*, Tomato, Horse-weed, Behavioral response

S5-1

Plants as a starting point for the development of nematode control agents

Mwamula Abraham Okki and DongWoon Lee
Department of Entomology, Kyungpook National University

The global nematicide market continues to grow. However, with increasing demand for synthetic chemical-free foods, plants have always offered a promising alternative in form of botanical nematicides. Application in soil has always been in form of crude extracts or raw plant materials like leaves, seeds, oil cakes and whole plant. However, in recent years, there have been vigorous efforts towards identification and commercialization of the most promising plant active secondary metabolites, including glucosinolates, especially their hydrolysis products such as isothiocyanates; flavonoids, alkaloids, limonoids and the more recently probed essential oils, among others.

Key words: Botanical nematicide, eco-friendly control agent, essential oil, plant parasitic nematode

S5-2

An analysis of the needs of facility farmers and nematode pesticide market for soil nematode

Gyoung Moo Kim
Cheongmyeong-Agris, Digital Agricultural Research Institute KM

최근 시설재배에서 작물에 대해 토양선충 피해가 심하며 아예 농사를 포기하는 농가가 증가하는 추세에 있다. 눈에 잘 보이지 않기 때문에 예찰이 힘들고, 방제약제를 사용해도 관리가 쉽지 않은 게 현실이다. 이러한 문제를 해결하기 위해 많은 연구가 이뤄지고 다양한 방제법 소개되어 현장에서 이용되고 있으나, 여전히 토양선충에 대한 농가들의 인식, 농작업 문제 등으로 여전히 효율적인 관리가 되지 않아 토양선충에 대한 피해 증가되고 있는 실정이다. 이러한 문제점을 해결하기 위해 토양 선충에 대한 시설농가들의 Needs 즉 시설작물 재배 시 관심사나 애로사항 기존 경험했던 토양선충에 대한 방제 경험들을 파악하여 현실적으로 농가에서 원하는 방제 방법 모색 해 보고, 현재 방제 솔루션 중에서 가장 많이 사용되고 있는 화학적 방제법인 토양선충 농약 시장의 과거와 현재를 분석하여 앞으로의 현장에 맞는 효과적인 토양 선충방제 체계를 모색하는 계기가 되었으면 한다.

검색어: 토양선충, 시설농가 Needs, 토양선충 농약시장분석

S5-3

Damage and management strategy for plant parasitic nematodes in korea

Chang-Seop Moon, Hyo-Jeung Byun and Suk-Jun Lee,
Dongbangagro Technical Research Institute, Buyeo 33216, Korea

국내 과채류 시설재배지 면적은 30,708ha(2021. KOSIS)로 단지화 등으로 인해 연작 장해가 문제가 되고 있는데 최근에 식물기생선충의 발생과 피해가 확산되고 있는 실정이다. 식물기생성선충은 주로 토양에 서식하면서 작물의 뿌리에 피해를 주어 수량과 품질 저하를 유발시킨다. 선충의 종류로 뿌리혹선충(*Meloidogyne* spp.), 씨스트선충(*Heterodera* spp., *Globodera* spp.), 뿌리썩이선충(*Pratylenchus* spp.) 등이 있다. 그 중에 대표적인 선충인 뿌리혹선충은 국내 시설재배지의 약 50%이상 발생하고 기주 범위가 넓어 많은 농작물에 피해를 주고 있다. 뿌리혹선충에 의한 피해를 감소시키기 위한 방제방법으로 비화학적 방제법(윤작, 태양광 소독, 저항성작물 재배 등)이 있지만 좀 더 효율적인 방제를 위해 화학적 방제법(살선충제, 훈증제)를 사용하고 있다. 최근에는 친환경 바이오 살선충제에 대한 관심과 수요도 증가하고 있다. 하지만 화학적 방제는 선충을 관리하는 효과적인 수단으로 여전히 큰 시장 점유율을 차지할 것으로 보인다. 따라서 현장에서의 경험을 토대로 식물기생성선충에 대해 소개하고자 한다.

검색어: 뿌리혹선충, 살선충제, 화학적방제, 과채류

S5-4

Current status and future direction of nematicide development in global market

Panjung Ha
Innovative Technology Department, Farmhannong Co., Ltd

식물기생성선충은 전 세계적으로 널리 분포하면서 연간 약 13% 수확량 감소를 일으키는 문제 해충이다. 다양한 식물기생성선충 중 뿌리혹선충과 시스트선충의 방제요구가 높으며 시장 또한 뿌리혹선충이 44%, 시스트선충이 22%로 가장 많이 차지한다. 글로벌 살선충제 시장은 연평균 성장률 3.3%로 완만한 성장성을 유지하고 있다. 사용되고 있는 살선충 계열은 훈증제, 유기인계, 카바메이트계가 전체의 80% 이상을 차지할 정도로 핵심적인 위치를 점하고 있었으나, 고독성 이슈로 인해 친환경적이며 독성인 낮은 새로운 살선충제 개발의 요구가 증가하고 있다. 본 발표에서는 글로벌 살선충제 시장현황과 국내외 주요 살선충제 개발 사례를 소개하고 글로벌 진출을 위한 개발 방향을 제시하고자 한다.

검색어: 식물기생성선충, 살선충제, 친환경, 저독성, 글로벌 시장

S5-5

Global nematicides market trend and R&D strategies of leading companies

Taek Su Shin, Jae Sung Im, Min Seop Cho and Hyun Hoo Park
R&D Center of Solvum Co., Ltd., 75 Techno 1-ro, Yuseong-gu, Daejeon 34014, Korea

최근 10년 동안 농산업에서 살선충제 연구에 대한 관심과 시장규모가 급격히 증가하고 있다. 주요 작물에 대한 선충의 감염은 작물 수확량 감소 및 경제적 손실을 발생시키며 이를 해결하기 위한 화학농약의 사용량 증가로 환경오염 및 잔류/독성 문제가 지속적으로 대두되고 있다. 따라서 우수한 살선충 효과와 환경에 대한 안전성이 높은 친환경 살선충제 연구가 급격히 증가하고 있으며, 주요 글로벌 기업들의 생물학적 소재를 활용한 제품 개발과 시장 진출에 대한 관심이 증가하고 있다. 살선충제 글로벌 전체 시장은 2020년 기준 약 USD 1.3 billion 규모의 시장을 형성하고 있으며 CAGR(2021~2025) 3.4%로 성장하여 2025년에는 약 USD 1.6 billion으로 성장할 것으로 예측되고 있다. 살선충제 중에서 생물학적 소재를 이용한 bionematicides 시장은 2021년 기준 USD 220.3 million 규모를 형성하고 있으며 CAGR(~2026) 16.9%로 매년 고속성장하여 2026년 USD 480.95 million 규모를 형성할 것으로 예측된다. 화학적 소재 기반 살선충제의 환경 및 생태 오염 문제와 건강에 대한 소비자 요구도를 충족하기 위해 생물학적 소재를 기반으로 한 bionematicides의 수요가 주요 시장 중심으로 급격히 증가하고 있다. 이에 따라 살선충제 시장을 선도하기 위한 글로벌 농화학 기업과 전문기업들을 중심으로 작물 및 대상 선충에 특화된 혁신적인 제품 개발 연구에 많은 투자를 하고 있다. 주요 선도기업으로 Bayer AG, Syngenta Crop Protection AG, Corteva Agriscience, BASF SE, FMC, Nufarm 등 글로벌 농화학 기업과 Isagro Group, Valent USA, Certis USA, Marron Bio Innovations 등의 전문기업들이 있다. 화학적, 생물학적 살선충제 연구개발에 대한 주요 관점은 1) 대상 선충에 대한 선택적 작용, 2) 생태 독성이 낮은 환경 안정성, 3) 사용자 안전확보 및 편리성으로 위의 관점이 상용화 제품으로 연결되어야 시장을 선도할 수 있는 제품으로 성장할 수 있을 것이다.

검색어: 살선충제, 생물학적 방제제, 시장동향, 선도기업, R&D 전략

Oral Presentation

PD1

Identification of two diamondback moth parasitoids, *Diadegma fenestrale* and *Diadegma semiclausum*, using LAMP for application in biological control

Hwa Yeun Nam[1] and Juil Kim[1,2]

[1]Agriculture and Life Science Research Instituite, Kangwon National University

[2]Program of Applied Biology, Division of Bio-resource Sciences, CALS, Kangwon National University

The diamondback moth, *Plutella xylostella* L., is known as a widely distributed destructive pest of Brassica vegetables worldwide. Various biological controls, such as parasitoid wasps, have been used to control this pest. Among these parasitoid wasps, *Diadegma semiclausum* and *Diadegma fenestrale* are widely used globally. The taxonomy of these two species based on morphological characteristics is very similar, and they are both parasitic on *P. xylostella* larvae. Therefore to be able to accurately differentially identify these species, in this study, we developed a molecular diagnostic method using loop-mediated isothermal amplification (LAMP). *D. fenestrale* species-specific primers for LAMP were designed in COX3, and the optimal diagnostic conditions for the four primers (F3, B3, FIP, BIP) was at 63 °C for 35 min. A species-specific primer capable of classifying *D. semiclausum* was established from the ITS2 region, and the optimal condition for diagnosis was 40 min at 63 °C. The diagnostic limit concentration was up to 10 pg under both optimal conditions; therefore, it was feasible to detect even very low concentrations. The developed LAMP diagnostic method can be used in a variety of ways to diagnose whether *P. xylostella* has been parasitized in the process of field research and mass breeding, and to accurately distinguish the species that are parasitic on *P. xylostella* larvae.

Key words: *Plutella xylostella*, *Diadegma semiclausum*, *Diadegma fenestrale*, LAMP, diagnostic method

PD2

Simultaneous control of sacbrood virus (SBV) and *Galleria mellonella* utilizing an improved Bt strain that producing dsRNA targeting the SBV *vp1* gene

Min Gu Park[1], Jae Young Choi[1], Dong Hwan Park[2], Minghui Wang[2], Sang Hee Kim[2], Ho Yeon Lee[2] and Yeon Ho Je[1,2]

[1]Research Institute for Agriculture and Life Sciences, Seoul National University, Seoul, Republic of Korea

[2]Department of Agricultural Biotechnology, Seoul National University, Seoul, Republic of Korea

The Asian honey bee, *Apis cerana*, is threatened by sacbrood virus (SBV) and by the greater wax moth, *Galleria mellonella*. Recently, RNA interference (RNAi) has been suggested as a promising strategy for the suppression of honey bee viruses. In addition, *Bacillus thuringiensis* (Bt) has been widely used for the control of lepidopteraen pests, such as *G. mellonella*. For the simultaneous control of both SBV and *G. mellonella* utilizing an improved Bt that produces dsRNA targeting the vp1 gene of SBV, the plasmid pMBD-1ABC-dsVP1 was introduced into the Bt strain 4Q7, which expresses various from Cry1Ac, Cry1Be, and Cry1C toxins. SBV replication was suppressed in A. cerana worker bees when they ingested dsRNA produced by the Bt transformant. Crystal proteins from the transformant Bt showed a high level of insecticidal activity against the 4th instar larvae of *G. mellonella*. These results demonstrated that a Bt-based, dsRNA-producing system could be efficiently exploited for the control of both SBV and *G. mellonella* simultaneously.

Key words: *Bacillus thuringiensis*, insecticidal proteins, *Apis cerana*, sacbrood virus, *Galleria mellonella*

PD3

A systematic and ecological study on the collembola in well-preserved habitats (Focusing on caves)

Gyu-Dong Chang
Department of Agricultural Biology, National Institute of Agricultural Sciences

본 연구에서는 제주도 거문오름용암동굴계에 속하는 13개의 용암동굴과 평창, 문경, 정선 지역에 위치한 석회암동굴 8개, 국립공원 및 DMZ 지역을 조사하여 총 3목 23과 47종의 톡토기를 동정하였다. 이중 총 13종 (신종 6종, 미기록 4종, 재기재 3종)을 새롭게 기재하였고, 종의 명확한 분류학적 위치지정을 위하여 필요한 경우 형태분석뿐만 아니라 미토콘드리아 COI gene을 이용하여 분자계통분석을 수행하였다. 특히 장암굴 (강원도 평창군)에서는 분류학적 연구를 바탕으로 생태학적 연구도 함께 수행하여 동굴 내부에 서식하는 톡토기와 환경인자 (토양온도, 토양습도, 토양 pH, 대기온도, 대기습도) 간의 상관관계를 분석하였다. 그 결과 장암굴 내부의 환경인자와 톡토기의 분포 및 종 다양성에는 상관관계가 없는 것으로 나타났다.

검색어: 용암동굴, 석회암동굴, 가시톡토기, 동굴생태연구, 유전적 거리 분석

PD4

Sampling unit of *Ricania* sp. (Hemiptera: Ricaniidae) eggs in persimmons

Sunghoon Baek, Miji Jeon, Seunghwan Lee, JiSu Jeong and Chang-Gyu Park
Department of Industrial Entomology, Korea National College of Agriculture and Fisheries

This study was conducted to determine an optimal sampling unit of *Ricania* sp. (Hemiptera: Ricaniidae) eggs in persimmons. First of all, the within-tree distribution pattern of its eggs was characterized with 60 persimmon trees by cutting 12 branches at four horizontal criteria (east, west, south, and north) in three vertical levels (basal, middle, and terminal parts) per tree. In numbers of egg masses, there was no significant difference ($P > 0.05$) horizontally, but significant ($P < 0.05$) difference vertically (more eggs were found at the tips of branches). Then, the sample unit of the selected branches was determined based on coefficient variation and coefficient of determination calcuated from egg mass numbers per 10 cm from the tip within a branch. The 60-cm branch tip was selected as the optimal sampling unit for *Ricania* sp. in persimmons. Finally, the required number to satisfy the sampling purpose was determined by using Reusink's equation. By considering damage recognizable level of *Ricania* sp., three 60-cm branch tips per tree would be generally acceptable in its management in persimmon fields.

Key words: *Ricania sp.*, persimmon, within-tree distribution, sampling unit

PD5

Establishment of control strategy using entomopathogenic fungi to forest pest Japanse pine sawyer beetle, *Monochamus alternatus*

Jong-Cheol Kim[1], Tae Young Shin[1], So Eun Park[1] and Jae Su Kim[1,2*]
[1]Department of Agricultural Biology, College of Agriculture & Life Sciences, Jeonbuk National University
[2]Department of Agricultural Convergence Technology, Jeonbuk National University

Japanse pine sawyer, *Monochamus alternatus*, is the main pest that mediates pine wilt nematode, *Bursaphelenchus xylophilus*, that causes serious damage to pine forests. In this study, we studied the strategy to control *M. alternatus* using entomopathogenic fungi, *Beauveria bassiana* ERL836 and *Metarhizium anisopliae* JEF-197, that showed high virulence against *M. alternatus* adults. The fungal isolates were evaluated for insecticidal activity against *M. alternatus* by spray treatment on live pine trees and wintering trees. Both isolates showd a high insecticidal activity against JPS, and the possibility of replacing chemical fumigants was evaluated. In addition, the interaction of fungi and *M. alternatus* were analyzed by RNA-seq. This result can contribute to the development of insect control agents using entomopathogenic fungi.

Key words: biopesticide, control strategy, entomopathogenic fungi, *Monochamus alternatus*, RNA sequencing

PD6

Chromosomal level of the genome sequencing and genome wide discovery lncRNAs involved in insecticide resistance in *Helicoverpa armigera*

Md Mafizur Rahman[1], Hwa Yeun Nam[2], David G. Heckel[3] and Juil Kim[1,2]
[1]Program of Applied Biology, Division of Bio-resource Sciences, CALS, Kangwon National University
[2]Agriculture and Life Science Research Institute, Kangwon National University
[3]Department of entomology, Max Planck Institute for Chemical Ecology, Germany

Since, CYP337B3 which is one of the most deeply identified cytochrome P450 genes involved in pyrethroid insecticide resistance from Australasian of *H. armigera* (resistance ratio, RR, was around 40 folds), we tried to identify novel resistant related genes in Korean populations. Because Korean populations showed an extremely high level of resistance based on LC50 values (RR >1,000) than that of Australasian populations. From that point of view, we focused on the chromosomal level of the genome sequencing, and Illumina, nanopore platform was applied. About 390Gb and 1,211 Scaffolds of genome draft were set (ASM1716586v1). Combining Hi-C analysis, we finally set the 31 pseudo chromosomes. Based on this genome draft, a total of 8,394 long non-coding RNAs (lncRNA) were surveyed in 45 transcriptome data sets. Some of the lncRNAs showed a high level of inverse correlation to the insecticide-resistant related cytochrome P450 genes such as CYP337B3 and CYP321A1 genes. These results suggested that not only coding RNA but also lncRNA possibly involved in the pyrethroid insecticide resistance in *H. armigera*.

Key words: genome sequencing, lncRNA, trascriptome, *Helicoverpa armigera*

PD7

Modeling distribution and risk index of *Vespa velutina nigrothorax* in Korea

Min-Jung Kim[1,2], Seong bin Bak[3] and Chuleui Jung[1,3]
[1]Agricultural Science and Technology Research Institute, Andong National University
[2]Forest Entomology and Pathology Division, National Institute of Forest Sciences
[3]Department of Plant Medicals, Andong National University

등검은말벌은 2003년 국내에서 처음 보고된 이후 꿀벌 전문포식자로서 양봉농가 피해는 물론 토착 말벌 군집에 위협 등으로 2019년 환경부 생태계교란생물로 지정된 바 있다. 현재는 침입 이후 전국으로 확산되어 국내 생태계에 정착한 것으로 판단된다. 이에 국내 서식처 환경과 연관한 분포 특성을 파악하고자 전국 발생 상황을 트랩으로 조사하고, 기후 조건 및 경관 특성에 따른 밀도 발생 패턴을 분석하였다. 등검은말벌 조사지점의 밀도를 4단계의 발생 수준으로 변환 후 역거리가중법을 이용하여 시각화하였다. 변환된 발생 밀도를 설명하기 위해 9개의 생물기후변수와 각 지점당 1km 반경 내 7개의 경관 요소를 환경변수로 이용하여 다중 회귀분석을 실시하였다. 검토한 변수들 중 5개의 생물기후변수와 4개의 경관 요소가 등검은말벌의 밀도에 영향을 주는 것으로 추정되었다. 선정된 변수들을 입력 변수로 등검은말벌의 발생 확률 및 밀도 수준을 각각 랜덤포레스트 알고리즘을 이용하여 모형화하였다. 모형의 기여도는 기후변수 중에서 기온의 계절적 변동 수준이, 경관변수 중에서는 산림의 면적비율이 가장 중요한 설명 변수인 것으로 나타났다. 현재 등검은말벌은 경상도, 전라남도, 충청남도 지역에 발생 밀도가 높고 해안을 제외한 강원도와 제주도에서 발생 밀도가 낮을 것으로 예측되었다. 모형 예측 밀도와 양봉 농가 분포 자료를 바탕으로 등검은말벌 피해 위험 지수를 산출하였다. 이 결과는 양봉 농가의 등검은말벌 피해 방지 계획 도출 및 생태계교란 생물 국가 관리 전략에 활용될 수 있다.

검색어: 등검은말벌, 생물기후변수, 경관 요소, 발생밀도예측, 랜덤포레스트

PD8

Chronic exposure to field-realistic doses of imidacloprid resulted in biphasic negative effects on honey bee physiology

Sanghyeon Kim[1] and Si Hyeock Lee[1,2]
[1]Research Institute for Agriculture and Life Sciences, Seoul National University
[2]Department of Agricultural Biotechnology, College of Agriculture and Life Science, Seoul National University

In this study, in order to investigate the effects of chronic imidaclorpid (IMD) exposure on honey bees, honey bee colonies were chronically exposed to field-realistic doses (5, 20, and 100 ppb) of IMD, and the body weight, flight performance, and carbohydrate reserve of forager bees were analyzed. IMD induced a biphasic change in body weight of the forager bees: decrease at the low concentration range (5 and 20 ppb) but increase at the high concentration (100 ppb). Nevertheless, the flight capability of forager bees significantly decreased in a concentration-dependent manner. The effects of IMD on target genes in forager bees showed biphasic patterns, whereas nurse bees showed typical features of premature transition to foragers in a concentration-dependent manner. Taken together, these results suggest that field-realistic doses of IMD alters honeybee energy metabolism in distinctly different mechanisms at low and high concentrations, both of which negatively affect honey bee colony health.

Key words: honey bee, imidacloprid, chronic exposure, diabetes, carbohydrate metabolism, biphasic effect

O1

Sniffing mosquitoes: Transcriptomic analyses of olfactory gene evolution in Culicomorpha (Diptera)

Woo Jun Bang and Seunggwan Shin
School of Biological Sciences, Seoul National University, Seoul, 08826, South Korea

The infraorder Culicomorpha is one of the monophyletic groups in the lower Diptera and consists of eight families: Ceratopogonidae, Chaoboridae, Chironomidae, Corethrellidae, Culicidae, Dixidae, Simuliidae, and Thaumaleidae. It has four blood-sucking families referred to as mosquitoes (Culicidae), biting-midges (Ceratopogonidae), frog-biting midges (Corethrellidae), and black files (Simuliidae). Even though the vector species in families Ceratopogonidae and Culicidae have been well-studied medically, the phylogenetic studies were poorly conducted from a perspective of hematophagous in this group. In this study, the olfactory receptors, which are important for host-seeking function, were identified and analyzed based on the transcriptome data. The protein family annotation was conducted using at least two genus per families representatively, except for the family Thaumaleidae. The comparative transcriptomic analysis reveals the number of olfactory receptors in blood-sucking families is higher than that of non-bloodsucking families. Furthermore, it was estimated that the gain-loss of olfactory genes appeared diverse during speciation, also in family-level.

Key words: Culicomorpha, gene annotation, hematophagous, olfactory receptor, transcriptomics

O2

Comparative population genetics using DNA barcodes revealed an invasion of differential grasshopper from the United States to Korea

Jiseok Kim and Donghun Kim
Department of Vector Entomology, Kyungpook National University, Sangju, Rep. of Korea

Invasive species are unintentionally introduced into new areas through the international trade. They are able to cause a variety of impacts on agricultural environment as well as biodiversity. In 2018, the differentialis grasshopper, *Melanoplus differentialis,* was firstly identified in Ulsan, Korea. The spread of *M. differentialis* caused economic losses due to the lower quality of agricultural crop and costs for pest management. In order to identify the origin of *M. differentialis* population in Korea, the population genetics were analyzed using DNA barcodes from populations distributed throughout the North America. The 254 differential grasshoppers were collected from both Ulsan, Korea and America including eight states in the U.S. and two states in Mexico. The genetic variation among populations was analyzed by using four different mitochondrial genes: NADH dehydrogenase subunit 2 (ND2), mitochondrial cytochrome oxidase subunit I (mtCOI), mitochondrial cytochrome oxidase subunit II (mtCOII), and Cytochrome B (CytB). The populations in America were mainly divided into Southern and Northeastern U.S. populations on the basis of principal coordinate analysis (PCoA) using pairwise F_{ST} values. The TCS network and PCoA revealed that the Korean population were genetically close with Southern U.S. populations except Mississippi and shared more than one haplotype. The Korean population showed fewer haplotype diversity and the number of haplotypes was two, two, one, and four, respectively. Genetic variation between populations might be generated from the geographical separation, including mountains and geographical distance. Taken together, we suggest that Ulsan population of *M. differentialis* was likely invaded from the Southern U.S. including Texas and Louisiana via international trade.

Key words: DNA barcode, population genetics, the differential grasshopper, invasive insects

O3

Taxonomic revision of Hypenodinae from Korea, with annotated checklist (Lepidoptera: Erebidae)

Ji-Young Lee and Bong-Kyu Byun
Department of Biological Science and Biotechnology, Hannam University, Korea

This study was conducted to review of the subfamily Hypenodinae with taxonomic arrangement in Korea. Totally 13 species under 7 genera are recognized from Korea. Also, its phylogentic status of the subfamily, which has been confused to date, was reconstructed and discussed through molecular and phenetic analyses respectively. In this study, one species: *Hypenodes turfosalis* (Wocke, 1850), was treated as synonym of *H. humidalis* Doubleday, 1850. Also, one species and two subspecies: *Parens* sp. nov. 1, *Anachrostis* ssp. nov. 1 and *Micreremites* ssp. nov. 1 is described as new to science. Totally 2 subspecies of 13 species of 7 genera under 2 tribes was recognized from Korea. All the known species were redescribed with the adults and genitalic structure and key to the species was provided. Also their all available information, including the result of biological observation, distributional ranges and host plants is enumerated.

Key words: Lepidoptera: Erebidae, Hypenodinae, *Parens*, new species, new subspecies

O4

Differential evolution of Argonaute protein in the genus *Drosophila*

Won Hee Ko[1], Sangil Kim[1,2] and Seunggwan Shin[1*]
[1]School of Biological Sciences, Seoul National University, Seoul, 08826, Republic of Korea
[2]Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA 02138, USA

In invertebrates, innate immune system takes important immunity role because of a lack of adaptive immune systems such as antigen-specific antibodies and receptors. RNA interference (RNAi) is one of the most important innate immune systems in insects. Short interference RNA (siRNA) acts as an anti-viral role in the case of Diptera, and the Argonaute protein plays a critical role in it. We used the genus *Drosophila* (26 *Drosophila* species) to find a significant evolutionary signal in the antiviral immune system. We investigated Argonaute protein orthologs among the whole body CDS (coding sequence) from 26 *Drosophila* species using OrthoFinder v.2.5.4. The Ago2, which is one of the subfamily members of Argonaute protein, was noticeably duplicated in different *Drosophila* subgroups such as the *D. obscura* group. Therefore, Ago2 gene structural analyses showed that the evolutionary rate and sequence variation of Ago2 protein are relatively higher than the Ago1 in this study. Furthermore, unlike Ago1, we found specific domain differences contributing to the overall increase of Ago2 protein substitution rate.

Key words: Argonaute protein, *Drosophila*, Bioinformatics, innate immune system

O5

New suggestions for taxonomic position of Varroa mite

Jaeseok Oh[1] and Seunghwan Lee[1,2]

[1]Laboratory of Insect Biosystematics, Department of Agricultural Biotechnology, Seoul National University

[2]Research Institute of Agriculture and Life Sciences, Seoul National University

Genus *Varroa* is one of the most famous honeybee pests in the world. In 1904, Oudemans erected the genus *Varroa* in the family Laelapidae, since then many authors suggested its taxonomic positions through morphological analysis. Varroa mites have unique morphological characters such as hypertrichious setae, highly sclerotized broadened shields on both dorsal and ventral, reduction of the movable digit, and the absence of gnathosomal setae *h2*. For this reason, the genus *Varroa* was separated from the family Laelapidae to make their own family Varroidae by Delfinado & Baker (1974). In this study, we verified the taxonomic position of the genus Varroa through the phylogenetic analysis via 28s, 18s, ITS, and H3 genes, and morphological analysis to provide new suggestions that the family Varroidae returns to a tribe of the family Laelapidae.

Key words: *Varroa*, Varroidae, Laelapidae, Honeybee pest, Taxonomy

O6

Taxonomic notes on problematic species in Korean Nolinae (Lepidoptera: Nolidae)

Yeong-Bin Cha[1] and Yang-Seop Bae[1,2]

[1]Division of Life Sciences, College of Life Sciences and Bioengineering, Incheon National University, Academi–ro, Incheon 22012, South Korea.

[2]Bio–Resource and Environmental Center, Incheon National University, Academi–ro, Incheon 22012, South Korea.

The subfamily Nolinae Hampson, 1894 is the biggest group within the family Nolidae in Korea. Their small size, similar facies, and genitalia structure (especially *Nola* Leach) cause incorrect identify. As a result of recent study, several species are incorrectly identified until now, and discover as new species. Additionally, we discuss some of these species, with International Code of Zoological Nomenclature.

Key words: ICZN, review, misidentify

O7

Harrison's rule corroborated among nomadine Cuckoo Bees (Hymenoptera: Apidae: Nomadinae): Role of Body Size in Host-switching Dynamics

Kayun Lim[1], Seunghyun Lee[1,2], Michael C. Orr[2] and Seughwan Lee[1,3]
[1]Insect Biosystematics Laboratory, Department of Agricultural Biotechnology, Seoul National University
[2]Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences
[3]Research Institute of Agriculture and Life Sciences, Seoul National University

Harrison's rule, which represents the positive body size correlation between parasites and hosts, has been reported in a range of taxa, but whether the rule can be applied to cleptoparasitic insects is poorly understood. Subfamily Nomadinae, the largest cleptoparasitic bees, usurp the nests of host bees and lay their eggs. As the hosts prepare the cells with pollen balls for the offspring, the parasitic larvae consume the pollen and develop in the nest until they become adults. Nomadinae invade various host families and especially genus *Nomada* exploits the most diverse hosts in that ten genera have been documented as their host information. Not only the diverse hosts but the nomadine bees are also remarkably diverse in size, indicating the ideal model to test Harrison's rule. Here, we reassess the phylogeny of Nomadinae, including the expanded sampling of the genus *Nomada* to elucidate host shift fluctuation through the evolutionary dynamics and applicability of Harrison's rule in the subfamily.

Key words: Nomadinae, body size evolution, cleptoparasitism, Harrison's rule, phylogeny

O8

A review of the genus *Spulerina* (Lepidoptera: Gracillariidae) from Korea

Da-Som Kim[1], Jae-In Oh[2] and Bong-Kyu Byun[2]
[1]National Science Museum, Daejeon, Korea
[2]Department of Biological Science and Biotechnology, Hannam University, Daejeon, Korea

This study was conducted to review of the genus *Spulerina* Vári, 1961, belonging the subfamily Acrocercopinae of the family Gracillariidae, from Korea. The genus *Spulerina* was established by Vári in 1961, including 20 described species worldwide. In this study, a total of 6 species are recognized from Korea. Among them, three species, *Spulerina corticicola* Kumata, 1964, *S. parthenocissi* Kumata & Kuroko, 1988 and *S. virgulata* Kumata & Kuroko, 1988 is reported for the first time from Korea. All available information, including check list, host plants and images of adults and genitalia for species is provided.

Key words: Gracillaridae, *Spulerina*, new record, leaf-miners, Korea

O9

A systematic study based on the endophallic structure of the genus *Aulonocarabus* (Coleoptera: Carabidae), with new subspecies from Korea.

Taeyeong Kwon, Eun Young Choi, Jong Bong Choi, Myeong Cheol Kim, Hee Soo Lee and Jong Kyun Park
College of Ecology and Environmental Science, Kyungpook National University, Sangju, Korea

In Korea, a total of four species of the genus *Aulonocarabus* were recorded. Moreover, the species included in this group are known to be endemic to Korea only. However, external morphological characteristics of this group are highly similar, which makes morphological examination difficult. Therefore, morphological study was conducted based on the endophallic structure and molecular phylogenetic using the *ND5* sequence, a mitochondrial gene, was additionally performed. In addition, the methods mentioned above are used to report the new subspecies of *A. semiopacus*.

Key words: Carabidae, *Aulonocarabus*, Endophallus, Systematics, New subspecies.

O10

Cryptic diversity between specific populations and cases of sympatry of epigean leptonetid spiders (Araneae: Leptonetidae) in South Korea

Jong-Hwa Oh[1], Sora Kim[3] and Seunghwan Lee[1,2]
[1]Laboratory of Insect Biosystematics, Department of Agricultural Biotechnology, Seoul National University
[2]Research Institude of Agricultrue and Life Sciences, Seoul National University
[3]Laboratory of Insect Phylogenetics and Evolution, Department of Plant Protection & Quarantine, Jeonbuk National University

Leptonetidae are tiny (1-3mm) rarely encountered spiders, mainly inhabiting in moist environments such as caves, leaf litters, and rock piles. Because they are microhabitat specialists, most species are known to have a limited distribution range, rarely having sympatries only found in few epigean populations. In this study, we conducted a test of DNA barcoding with Korean Leptonetidae sampled from various mountains, islands, mines, and caves. 422 specimens representing 76 morphospecies were compared with number of MOTUs, generated by five species delimitation methods (ABGD, ASAP, GMYC, PTP, and bPTP). Our results also revealed many cases of multiple species sharing habitats, indicating sympatries occurring potentially on a nation scale, which are rare in leptonetids worldwide.

Key words: Leptonetidae, DNA barcoding, Species delimitation, Microhabitat, Sympatry

O11

Correlation of differential expression levels of NRRS and insecticidal activities of six different strains of *Xenorhabdus nematophila*

Eticha Abdisa and Yonggun Kim
Department of Plant Medicals, Andond National University

An entomopathogenic bacterium, *Xenorhabdus nematophila* is symbiotic to an entomopathogenic nematode, *Steinernema carpocapsae*. After entry to target insects, these nematodes release the symbiotic bacteria in the insect hemocoel. *X. nematophila* synthesizes various secondary metabolites using transcriptional activities of non-ribosomal peptide synthetase (NRPS) genes. This study demonstrated that the NRPS expression levels are correlated with the insecticidal activities using different bacterial strains of *X. nematophila*. Indeed, a mutagenesis to alter NRPS gene expression supports the functional correlation.

Key words: *Spodoptera exigua*, *Xenorhabdus nematophila*, NRPS, secondary metabolite, insecticidal activity

O12

Chymotrypsin as a molecular target of antibiotic resistance in three corn varieties by RNAi against Asian corn borer, *Ostrinia furnacalis*

Eun Young Kim[1,2], I Hyeon Kim[1], Jin Kyo Jung[1] and Yonggyun Kim[2]
[1]Crop Cultivation and Environment Division, Natl. Institute of Crop Science, RDA
[2]Department of Plant Medicals, Andong National University

조명나방(*Ostrinia furnacalis*)에 대해 해충 저항성을 보이는 세 가지 옥수수 품종 (일미찰, 광평옥, p3394)의 분자수준에서 내충성 기작을 이해하기 위해 본 연구를 수행하였다. 대조구로 사용한 인공사료 및 감수성 품종 (강원찰60호)으로 사육된 개체에 비해 유충 발육이 유의하게 저하되고, 유충 중장의 카이모트립신 활성이 50% 이상 감소하였다. 또한 카이모트립신 특이적 억제제 처리로 카이모트립신 활성을 억제시키면 유충 사망률이 증가되었다. 이를 통해 세 저항성 품종의 항생성 기작으로 카이모트립신을 분자 표적으로 설정하였다. 조명나방의 전사체에서 카이모트립신 유전자 9개를 얻었으며, 발현이 확인된 6개의 유전자 중 발현량이 가장 높은 *OfCHY3* 특이적 dsRNA를 유충에 주입 및 섭식시킨 결과 유전자 발현량이 크게 감소하였고, *OfCHY3* dsRNA를 발현하는 대장균 섭식실험에서도 유전자 발현량과 조명나방의 발육이 저하되었다.

검색어: 조명나방, RNAi, 카이모트립신, 항생성

O13

Diminished oxidative bioactivation is accountable for selective resistance to coumaphos in honey bees

Susie Cho[1], Kyungjae Andrew Yoon[2], Jiho Lee[3], Sanghyeon Kim[2], Joonhee Lee[1] and Si Hyeok Lee[1,2]
[1]School of Agricultural Biotechnology, Seoul National University
[2]Research Institute for Agriculture and Life Sciences, Seoul National University
[3]Korea Conformity Laboratories

Varroa destructor, an ectoparasitic mite, is a major threat to the western honey bees, *Apis mellifera*, which is the most important pollinator in agriculture. Varroa mites feed on honey bees and transmit viral infections to them. To combat varroa mites, a few synthetic miticides, such as fluvalinate, amitraz, and coumaphos, that meet the condition of high selectivity for varroa mites with low toxicity to honey bees are currently available for use in hives. The purpose of this research was to compare the toxicodynamic and metabolic properties of coumaphos in honey bees and varroa mites. To understand the molecular basis of selective coumaphos toxicity, we first investigated the toxicodynamic characteristics of AChEs from honey bees and varroa mites. We then examined the tissue distribution of representative P450s, the quantitative and qualitative profiles of coumaphos metabolites, and the functional properties of representative P450s in each species to compare the differences in coumaphos metabolism, with a particular focus on the differential detoxification and bioactivation of coumaphos between the two species. Finally, we evaluated the hypothesis that various phytochemicals can increase the varroa mite-specific toxicity of coumaphos by inducing the expression of the P450 responsible for coumaphos bioactivation in varroa mites. Thus, the possibility of further investigating the selective bioactivation mechanism in varroa mites for the development of novel synergists or/and additional proinsecticides with varroacidal action was explored.

Key words: honey bee, *Apis mellifera*, varroa mite, *Varroa destructor*, miticide, coumaphos, selective toxicity, cytochrome P450 (P450), metabolic factor, bioactivation, proinsecticide

O14

PGE_2 influence on chorion formation of Asian tiger mosquito, *Aedes albopictus*, through DEG transcriptome analysis during oogenesis

Du-yeol Choi and Yonggyun Kim
Department of Plant Medicals, College of Life Sciences, Andong National University

곤충 생식과정에서 알발육은 난모세포 생성 이후 난황형성과정이 일어난다. 이러한 과정에 인슐린유사펩타이드, 유약호르몬 및 탈피호르몬의 중개과정이 비교적 잘 알려져 있다. 그러나 이후 일어나는 난각형성과정에 관여하는 내분비 신호에 대해서는 잘 이해되고 있지 않다. 최근 아이코사노이드 가운데 PGE_2가 곤충의 생식과정에 관여한다는 것이 알려지고 있다. 본 연구는 흰줄숲모기(*Aedes albopictus*)의 난각형성과정에 관여하는 PGE_2의 영향을 분석하였다. 먼저 이 호르몬의 생합성을 억제하는 아스피린을 처리하면 난각형성이 둔화되는 것으로 관찰하였다. 다시 PGE_2를 추가하여 주면 난각형성이 회복되는 것을 관찰하여 PGE_2의 중개 기능을 증명하였다. PGE_2의 난각형성에 대한 기작을 알아보기 위해 난각형성관련 발현유전자들을 Illumina NovaSeq으로 분석하여 난각형성에 관여할 것으로 추정되는 864개의 DEG를 얻었다. 실제로 아스피린 처리 개체에서는 864개 중 57개 DEG들의 발현을 억제하였다. 이들 DEG에는 다수의 CRP, POX, CBP, VMP 등이 포함되었다.

검색어: 흰줄숲모기, 아스피린, PGE_2, 난각, 차세대 염기서열 분석, RNA 간섭

O15

An insect immunosuppressant, GameXPeptide, synthesis gene (*gxpS*) structure and its expression along with bacterial pathogenesis

Gahyun Jin and Yonggun Kim
Department of Plant Medicals, College of Life Sciences, Andong National University

A depsi pentapeptide called GameXPeptide (GXP) were identified in Xenorhabdus and Photorhabdus (X/P) bacteria, which are symbiotic to entomopathogenic nematode. GXP is synthased from a non-ribosomal peptide synthesis (NRPS) bacterial gene called *gxps*. Bacterial metabolite of 10 different X/P species produced GXP. *gxpS* genes were identifed in the 10 bacterial genomes. Expression of *gxpS* was increased along with bacterial growth. *gxpS* was highly expression at late bacterial growth phase. Manipulation of gxpS expression is now implemented by a mutagenesis using altering promoter activity.

Key words: entomopathogenic nematode, GameXPeptide, Xenorhabdus, Photorhabdus, *gxpS*, mutagenesis

O16

Functional analysis of olfactory receptors that detects disease (chalkbrood) smell in honey bees (*Apis mellifera*).

Seungha Lee, Sujin Lee, Dain Lee, Myeong-Lyeol Lee and Hyung Wook Kwon*
Department of Biological Sciences & Convergence Research Center for Insect Vectors, College of Life Science and Bioengineering, Incheon National University, Incheon, Republic of Korea

Chalkbrood is one of the rapidly spreading diseases in honeybees (*Apis mellifera*) that caused by fungal pathogen (*Ascosphaera apis*). The disease significantly repress brood growth and reproductivity of honey bee colonies. Phenethyl acetate has been known to a key compound associated with chalkbrood-infected larvae that induces hygienic behavior. The mechanism of hygienic action is triggered by the detection of chemical stimuli in diseased larvae and proceeds with the removal of diseased broods from the nest. Insect odorant receptors (ORs) are responsible for the detection of the relevant cues from diverse odorants including pheromones. Previous studies in *Drosophila melanogaster* odorant receptor (DmOr) have revealed that DmOr67a (NP_524005) and DmOr85d (NP_524281) act as phenethyl acetate receptor. The candidate odorant receptors in Apis mellifera (AmOrs) were selected via protein BLAST search (blastp) of those receptors. 6 candidate odorant receptors for phenethyl acetate were cloned and tested against 9 odorants stimuli by using *in vivo* cell calcium imaging after transfection into HEK-293 cells.

O17

Physiological role of 5-HT$_7$A and 5-HT$_7$B in salivary secretion and blood feeding behavior from the Asian tiger mosquito, *Aedes albopictus*

Seoyul Hwang and Donghun Kim
Department of Vector Entomology, Kyungpook National University

The success of mosquito blood feeding is accomplished by the secretion of saliva, which includes various bioactive molecules to suppress host's immune system as well as hemostasis including coagulation and platelet aggregation. Salivary secretion of mosquito is known to be controlled by serotonergic innervation into the salivary glands, where included proximal regions of both medial and lateral lobes. However, it is still unclear that which subtype of serotonin receptor (5-HT receptor) is mainly involved in the salivation of mosquito. In this study, two distinct 5-HT receptor subtype 5-HT$_7$, 5-HT$_7$A (1395bp) and 5-HT$_7$B (1431bp),were identified and characterized from the Asian tiger mosquito, *Aedes albopictus*. In heterologous expression system, Chinese hamster ovary (CHO) cells expressing 5-HT$_7$B were dose-dependently activated or inhibited by serotonin/agonists or antagonists, as indicated by elevated calcium mobilization. The transcripts of 5-HT$_7$A and 5-HT$_7$B were significantly higher in adult stages (minimum 1.2 to maximum 4.3-fold) than immature stages. Head and salivary glands of female mosquito were main tissues expressing 5-HT$_7$A and 5-HT$_7$B. The serotonin mediated mosquito salivary secretion was significantly decreased from female mosquitoes injected by dsRNA-5-HT$_7$A (46.5%), dsRNA-5-HT$_7$B (47.2%), and dsRNA-5-HT$_7$A and 5-HT$_7$B (58.2%), respectively. In addition, the blood feeding behavior of female mosquito such as probing and feeding was significantly prolonged up to 62.6% (13.8 seconds) and 62.7% (12.1 seconds) by RNAi, respectively. Thus, we suggested that 5-HT$_7$A and 5-HT$_7$B receptors play critical roles in the salivary secretion and feeding behavior of mosquito.

Key words: *Aedes albopictus*, salivation, 5-hydroxytryptamine receptor

O18

Bacterial metabolites of *Xenorhabdus hominickii* suppress cellular and humoral immune responses of *Spodoptera exigua* induced by *Bacillus thuringiensis* infection

Md Tafim Hossain Hrithik[1], Miltan Chandra Roy[1], Helge Bode[2] and Yonggyun Kim[1*]
[1]Department of Plant Medicals, Andong National University
[2]Max Planck Institute, Marburg, Germany

Different strains of *Bacillus thuringiensis* produce a diversity of Cry proteins that are selectively toxic to insect pests. Bacteria of *Xenorhabdus* and *Photorhabdus* can synthesize secondary metabolites to induce host immunosuppression. Insect immune responses play crucial role to combat with *B. thuringiensis* infection. This study hypothesized that bacterial secondary metabolites can enhance the pathogenicity of *B. thuringiensis* subsp. *aizawai* (BtA) against *S. exigua*. An addition of *X. hominickii* (Xh) culture broth significantly enhanced the insecticidal activities of BtA. Addition of Xh metabolites such as 3-ethoxy-4-methoxyphenol, oxindole, benzylideneacetone, and GameXPeptide significantly enhanced BtA toxicity. Oral administration of BtA significantly induced AMP gene expressions whereas Xh culture broth or secondary metabolites can suppress AMP gene expression. In the meantime, Xh culture broth or secondary metabolites significantly suppressed nodule formation. The enhanced BtA toxicity by Xh culture broth or secondary metabolites showed significant control efficacy against *S. exigua* compared to BtA alone in field condition.

Key words: *Bacillus thuringiensis* subsp. *aizawai*, *Spodoptera exigua*, *Xenorhabdus hominikii*, secondary metabolites

O19

Molecular evidence for TSWV entry to thrips gut epithelium through glycoprotein and cyclophilin

Falguni Khan, Jean Lee and Yonggyun Kim
Department of Plant Medicals, Andong National University

The western flower thrips, *Frankliniella occidentalis* is a devastating pest insect that is responsible for transferring TSWV in different crops throughout the world. Cyclophilin (Cp) is a peptidyl-prolyl cis-trans-isomerase and involved in different biological processes such as protein folding, cell signaling, and immune responses. Endocuticle structural glycoprotein (G_N) is an integral membrane protein which plays an important role in cell–cell interactions. Cp and G_N are abundant in midgut and salivary gland of the thrips, and are supposed to interact directly to TSWV during larval stage. Cp and G_N of *F. occidentalis* encode 205 and 284 amino acids, respectively. Their expressions in different developmental stages were confirmed by RT-PCR. Knockdown of Cp or G_N expression was performed by feeding gene-specific dsRNAs. This RNA interference altered TSWV titer in the thrips compared to control.

Key words: *Frankliniella occidentalis*, TSWV, glycoprotein, cyclophilin

O20

Physicochemical properties and volatile compound profiles of fermented *Protaetia brevitarsis* by lactic acid bacteria and yeast

Ji Yoon Cha[1,2], Tae-Kyung Kim[1], Min-Cheoul Kang[1], Hwanhee Yu[1] and Yun-Sang Choi[1]
[1]Research Group of Food Processing, Korea Food Research Institute
[2]Department of Biotechnology, Korea University

Edible insects can be approached in food security as the food of future, and have excellent nutritional properties. Also, edible insects emit less carbon and have environmental advantages, compared to livestock food. However, edible insect-processed foods have negative consumer preferences and need to raise consumer awareness. Consumers do not prefer the unique flavor of edible insects, which limits the use fo edible insects. In this study, *P. brevitarsis* larvae was fermented with lactic acid bacteria and yeast to investigate physicochemical properties and changes in volatile compounds. There were a total of 32 volatile compounds detected before fermentation, and the composition of volatile compounds changed after inoculation with lactic acid bacteria. It showed the possibility of improving flavor by showing an increase in esters with odor of fruity or sweetness and pyrazines with odor of roast and nutty. Therefore, the fermentation process of an insect can be a method capable of improving flavor.

Key words: *Protaetia brevitarsis*, fermentation, volatile compounds

O21

Morph-specific life-history correlations in a wing dimorphic water strider

Hyoseul Hyun and Chang S. Han
Department of Biology, Kyung Hee University

Life-history theory predicts a negative correlation between reproduction and survival because individuals differ in their investment in early reproduction at the expense of survival. However, life-history trade-offs can be masked when individual differences in resource allocation are smaller than those in resource acquisition. In polymorphic species, as distinct morphs exhibit differences in intrinsic physiology, the relative effects of resource acquisition and allocation on life-history traits will differ between morphs, contributing to morph-specific life-history correlations. In the wing-dimorphic water strider Aquarius paludum, wing morphs differed in within-morph individual-level life-history correlations. Longer-lived long-winged females produced fewer eggs per day and matured later, whereas life-history trade-offs were not observed in short-winged females. We suggest that morph-specific effects of resource allocation trade-offs, such as wing muscle histolysis, can shape the morph-specific extent of individual variation in life-history strategies.

Key words: life-history, resource acquisition, resource allocation trade-off, water strider, wing dimorphism

O22

Effects of curcumin and rosmarinic acid on the detoxification of pesticide poisoning of honey bees

Daniel Bisrat[1], Tekalign Begna[3], Delgramaa Ulziibayar[3], Yong-Rak Kang[3], Saeed Mohamadzade Namin[1,2] and Chuleui Jung[1,3]

[1]Agricultural Science and Technology Institute, Andong National University, Republic of Korea

[2]Department of Plant Protection, Faculty of Agriculture, Varamin-Pishva Branch, Islamic Azad University, Varamin, Iran

[3]Department of Plant Medicals, Andong National University, Republic of Korea

Honeybees pollinate around one third of the world's crop species, but their population decline has raised concerns about the sustainable food production. Agrochemicals are the major factor in honeybee mortality and while foraging, honeybees are exposed to variety of pesticides which are being applied in crop production. In addition, they may bring contaminated pollen and nectar into hive. Curcumin (CU) is the active ingredient of the dietary spice turmeric and has been consumed for medicinal purposes for thousands of years. Since the anti-inflammatory, anti-oxidant and pro-apoptotic characteristics of CU has been confirmed previously, the present study was designed to determine the effects of CU and other closely related chemicals such as rosmarinic acid (RA) on reduction of mortality of the worker bees intoxicated with different pesticides. In this study, CU and RA supplemented food were evaluated for their potential in reducing the mortality of worker bees intoxicated with three concentrations of four (imidacloprid, Acetamiprid, Fenitrothion, and Flupyradifurone) and seven different pesticides (carbaryl, amitraz, Bifenthrin, acetamiprid, imidacloprid, flupyrodifurone and fenitrothion) respectively. RA supplemented feeding reduced honey bee mortality across all intoxicated concentrations of acetamiprid, flupyradifurone and amitraz while it cause a significant lower mortality when honey bees were subjected to imidacloprid, fenitrothion, carbaryl and bifenthrin at lower dose intoxication. In the honeybees intoxicated with Acetamiprid and flupyradifurone, CU supplemented feeding was effective in reducing honey bee mortality across all intoxicated concentrations however, it cause a significant lower mortality when honey bees were subjected to imidacloprid and fenitrothion at lower dose intoxication. According to our results, CU and RA supplemented foods have potential to be applied as an antidote in intoxicated colonies however, more colony level studies is required for confirmation.

Key words: Detoxification, honeybee, *Apis mellifera*, curcumin, Rosmarinic acid.

O23

Species diversity of Burkholderiaceae family colonizing in *Riptortus pedestris* (Hemiptera: Alydidae) following environmental acquisition

Do-Hun Gook, Minhyung Jung, Jung-Wook Kho, Joo-Young Kim, Soowan Kim and Doo-Hyoung Lee
Department of Life Sciences, Gachon University, Gyeoggi-do, South Korea

Understanding of species diversity of bacteria colonizing in *Riptortus pedestris* (Hemiptera: Alydidae) is essential to better understand evolutionary relationships with symbionts acquired from soil environment where diverse microbes exist. Therefore, in laboratory conditions, 2nd instar nymphs were provided field-collected soil and reared to adult. Then, bacteria colonizing in midgut crypts of *R. pedestris* were cultured and subject to species identification for characterizing species richness and evenness of the symbionts. From the experiments, 87% of bacteria belong to genus *Caballeronia*; *Paraburkholderia* (10%), *Burkholderia* (2%), and *Pandoraea* (2%) were followed. At species level, 14 species were identified; *C. jiangsuensis* (35%) and *C. megalochromosomata* (22%) were dominant species.

Key words: Bean bug, Endosymbiosis, Environmental acquisition, Species identification

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O24

Additive interactions of mixture of acetamiprid and emamectin benzoate to honeybees (*Apis mellifera*) adult and larvae

Tekalign Begna[1], Delgrimaa Uzbaayer[1] and Chuleui Jung[1,2]
[1]Department of Plant Medicals, Andong National University
[2]Agricultural science & technology research institute, Andong National University

Honeybees are exposed to mixture of insecticides when collecting foods. The present study investigated the effects of formulation of two individual pesticides and their binary mixture in the A.meliifera. Results revealed that acetamiprid + emamectin benzoate (ACT + EB) had the highest toxicities to A.mellifera with LD50 0.00004 (spray) and 0.001μg/bee (oral) and LC50 value of 0.162μg/ml in larvae. Further risk assessment showed, the hazard potential of both ACT + EB and emamectin benzoate (EB) were higher, spray hazard quotient (cHQ) = 500 and 28, 038 and oral hazard quotient (oHQ) = 100 and 170 respectively. Furthermore, the estimated additive indices (AI) indicated acetamiprid and EB interact additively with AI of 0.01, 0.047, and 0.02 in contact, oral, and larvae respectively. Repeated larvae exposure to ACT + EB significantly reduce survival than solvent and negative control. Our findings indicated ACT + EB has adverse effects on honeybee suggesting further study in field to avoid increased toxic effects by mixture of pesticides.

Key words: Formulations; Additive effect; Spray toxicity; Oral toxicity; acute exposure; repeated exposure

O25

Environmentally-transmitted symbiotic microbe provides overall enhancement on adult feeding and dispersal, but negatively affects longevity of insects

Minhyung Jung, Joo-Young Kim, Soowan Kim and Doo-Hyung Lee
Department of Life Sciences, Gachon University, Gyeonggi-do, South Korea

Symbiotic microbe facilitates assimilation of nutrient in direct and indirect ways, thereby affecting behavior and fitness of host insects. In this study, we evaluated effect of symbiosis on host insects, especially on adult longevity, feeding and dispersal behaviors and female fecundity using *Riptortus pedestris* (Hemiptera: Alydidae) and *Caballeronia insecticola* as a model system. We found significantly enhanced food assimilation efficacy and dispersal behavior including horizontal walking and flight in symbiotic insects compared to apo-symbiotic ones. By contrast, longevity of symbiotic insects especially for female was significantly reduced, yielding survivorship as 56% during 60-day period compared to male and apo-symbiotic ones. When we measured titer of *C. insecticola* weekly over 8-weeks, titer of symbiotic microbe was maintained at 10^7 cell on average in female, whereas that of male gradually decreased from 10^7 to 10^5 cell over 8^{th} week.

Key words: insect-microbe symbiosis, feeding behavior, flight ability, survivorship

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O26

Rapid cold hardening of small hive beetle *Aethina tumida* Murray

Muhammad Noor-ul-Ane[1*] and Chuleui Jung[1,2]
[1]Agricultural science & technology research institute, Andong National University, Andong, GB, Korea
[2]Department of Plant Medicals, Andong National University, Andong, GB, Korea

The small hive beetle (SHB) Aethina tumida Murray, (Coleoptera: Nitidulidae) is now a global invasive pest of honey bees. Insects use rapid cold-hardening (RCH) as a quick physiological response to increase their cold hardiness. Therefore, aim of study was to determine rapid cold-hardening in the small hive beetle and putative role of metabolites for rapid cold-hardening in most tolerant stage. The immatures stages of SHB were briefly exposed 12.5oC for 5 hours and then to 0oC for their respective lethal hours. All immature stages showed rapid tolerance to cold temperature. However, wandering larvae showed more survival because of rapid cold hardening as compared to other stages. Proline was highly elevated metabolite in wandering stage of SHB during rapid cold hardening. This study shows that SHB can tolerate sudden fluctuation of cold temperatures by initiating swift physiological change.

Key words: Honeybees; cold tolerance; metabolites; climate change

O27

Flash display increases prey survival against avian predators

Seong-Su No[1], Thomas N. Sherratt[2] and Chang-Ku Kang[1,2]
[1]Department of Biosciences, Mokpo National University
[2]Department of Agricultural Biotechnology, Seoul National University

위장색을 가지고 있는 피식자 중 일부는 화려한 색을 숨기고 있으며 이동 혹은 도주시에만 화려한 체색을 드러낸다. 이러한 숨겨진 화려한 체색은 포식자가 피식자의 평상시 체색이 화려한 색이라 착각하게 만들며, 피식자가 다시 정지하고 위장으로 몸을 숨기고 있을 때도 포식자가 눈에 띄는 색상을 계속 찾도록 혼란을 주는 효과가 있다. 이러한 피식자의 방어전략을 flash display라 부르며, 이러한 전략은 메뚜기, 나비, 조류 등 다양한 분류군에서 발견된다. 기존 연구에서 flash display 전략은 인간 포식자를 상대로 그 효용성이 검증되었지만, 실제 동물 포식자를 대상으로 그 효용성이 검증된 바가 없기에, 본 연구에서는 곤충의 주된 포식자인 조류(병아리)를 대상으로 flash display 전략의 효용성을 연구하였다. 조류 포식자에게 빔프로젝터를 이용하여 가상의 실험환경과 flash display를 보이며 도주하는 먹이를 보여준 뒤 생존율을 측정하는 방법을 활용하였으며, 1) flash display 가 조류 포식자에게 효과적인지, 화려한 색상을 가져야 효과가 있는지 2) 피식자의 몸 크기가 flash display 효용성에 영향을 주는지, 3) 포식자가 피식자의 위장한 모습을 확인하기 전 도주하는 것이 flash display 효용성에 영향을 주는지를 각각 독립적으로 검증하였다. 실험 결과 1) flash disiplay 는 조류 포식자를 상대로 생존율 증가 효과가 나타났고, 화려한 색상이 아니어도 효과가 있었다. 2) 크기가 큰 피식자와 작은 피식자에서 생존율 증가 효과는 큰 차이를 보이지 않았다. 3) 포식자가 피식자를 탐지 전 도주했을 때 생존율이 더 높았고, flash display 효과는 큰 차이를 보이지 않았다. 본 연구 결과는 flash display 가 실제 조류 포식자를 상대로 효과적인 방어전략이라는 것을 보여준다.

검색어: 위장색, 곤충 방어전략, 도주행동

O28

Escape behaviour is associated with hindwing coloration in grasshoppers

Won-Bin Lim[1,2] and Chang-Ku Kang[2]
[1]Department of Biosciences, Mokpo National University
[2]Department of Agricultural Biotechnology, Seoul National University

숨겨진 대비 색채 신호(hidden contrasting color signal) 중 하나인 flash display는 평상시에는 위장색을 가지고 있는 피식자가 포식자로부터 도주하는 중에만 화려한 색채를 보이는 것을 의미한다. 이러한 보호색은 곤충의 속날개에서 드물지 않게 진화하였으며, 도주 중에 화려한 색을 보임으로써, 포식자에게 자신의 평상시 색에 대한 혼동을 준다. 최근 연구에서, flash display는 긴 도주 시작 거리(FID; flight initiation distance)와 함께 작동할 때 효과적이며, 실제 조류를 상대로 한 연구에서 flash display를 가진 조류가 그렇지 않은 조류보다 더 긴 FID를 가진다는 것이 보고되었다. 본 연구에서는 이러한 관계가 flash display를 흔히 보이는 메뚜기과 곤충에서도 진화하였는지를 검증하였다. 이를 위해, 한국에 서식하는 메뚜기과 9종의 FID와 미국에서 보고된 9종의 메뚜기의 FID 자료를 이용하였다. 먼저 한국 메뚜기의 FID를 측정하기 위해 실험자가 메뚜기에게 다가가 도망가게 한 후 FID를 측정하였다. 미국 메뚜기의 FID는 기존에 출판된 Butler (2013)의 자료를 활용하였다. 연구 결과, 예측했던 바와 같이 flash display를 가진 종이 그렇지 않은 종보다 큰 FID 값을 가짐을 발견하였다. 또한 flash display가 상대적으로 큰 몸집을 가진 종에서 선택적으로 진화하였다는 사실도 밝혀내었다. 본 연구결과는 메뚜기과 곤충에서 도주행동과 flash display 가 공진화하였다는 것을 시사한다.

검색어: 메뚜기과, flash display, FID

O29

Sex differences in indirect effects on the escalation of aggressive displays of bean bugs *Riptortus pedestris*

Yi Hang Park and Chang Seok Han
Department of Biology, Kyung Hee University

최근 개체 수준의 행동 연구가 늘어나면서, 동물의 공격 행동이 개체마다 다른 수준으로 발현될 뿐만 아니라 (직접 영향, direct effect), 교류하는 상대방 개체에 따라서도 다르게 발현된다는 사실이 밝혀지고 있다 (간접 영향, indirect effect). 또한 같은 종 내에서의 공격 행동은 한 가지 형태가 아니라, 싸움이 진행되면서 공격 행동의 강도가 높아지며 순차적으로 여러 형태로 나타날 수 있다. 하지만 강도가 다른 여러 공격 행동에 대해 상대방 개체에 의한 간접 영향이 어떻게 다르게 나타나는지에 대한 연구는 아직 되어 있지 않다. 더 나아가, 강도가 다른 여러 공격 행동에서 나타나는 간접 영향 패턴이 수컷과 암컷에서 어떻게 다른지에 대해서도 아직 알려진 바가 없다. 본 연구는 톱다리개미허리노린재(*Riptortus pedestris*)를 대상으로 동성 개체 간에 무작위로 짝을 지어가며 반복적으로 1:1 대진을 기록했고, 수컷과 암컷 모두에서 나타나는 여러 공격 행동(1-leg kicking, 2-legs kicking, wing flaring, squeezing) 발현에 미치는 (1) 직접 영향과 (2) 간접 영향을 살펴보았다. 또한 각 공격 행동에 나타나는 직접 및 간접 영향에 양 성 차이가 어떻게 나타나는지에 대해서도 조사하였다. 연구 결과, 수컷은 암컷보다 모든 강도의 공격 행동이 더 높게 발현되었다. 수컷은 모든 공격 행동에 직접 영향이 존재했으며, 가장 강한 공격 행동(squeezing)을 제외한 나머지 공격 행동에 유의미한 간접 영향이 존재했다. 암컷은 일부 공격 행동(2-leg kicking and wing flaring)에만 직접 영향이 존재했으며, 가장 약한 공격 행동(1-leg kicking)에만 유의미한 간접 영향이 존재했다. 요약하면, 본 연구 결과는 공격 행동의 강도가 높아지면서 상대방이 공격 행동 발현에 미치는 영향(간접 영향)은 약해지며, 이러한 패턴은 양 성에서 모두 나타난다는 것을 보이고 있다. 이러한 사실은 공격 행동의 진화에 미치는 상대방의 영향이 강도에 따른 공격 행동의 종류마다 다를 수 있다는 것을 시사한다.

O30

Comparative analysis of cold tolerance of two flower thrips (*Frankliniella occidentalis and F. intonsa*) and prediction of their overwintering sites in hot pepper fields

Chul-Young Kim, Du-Yeol Choi, Dong-Hyun Lee and Yong Kyun Kim
Department of Plant Medicals, Andong National University

시설 재배지 고추에 주요 총채벌레는 꽃노랑총채벌레(*Frankliniella occidentalis*)과 대만총채벌레(*F. intonsa*)이다. 본 연구는 이들 총채벌레의 월동 생리를 분석하는 데 목적을 두었다. 두 총채벌레는 동결감수성 곤충으로 낮은 온도(-15～-25℃)에서 체내빙결점을 보였다. 그러나 이 체내빙결점은 두 곤충 종 사이에 그리고 발육시기에 따라 상이하였다. 꽃노랑총채벌레의 경우 성충 –25.7±0.5℃, 번데기 –17.2±0.3℃, 유충 –15.0±0.4℃를 각각 나타냈고, 대만총채벌레는 성충 –24.0±1.0℃, 번데기 –26.9±0.5℃, 유충 –17.2±0.8℃을 각각 기록하였다. 그러나 실제로 저온 피해는 체내빙결점 보다 높은 온도에서 일어났다. 저온 노출 실험에서 처리온도가 내려갈수록 그리고 노출시간이 증가할수록 저온 피해가 증가하였다. 대만총채벌레에 비해 꽃노랑총채벌레가 저온에 대해서 높은 내한성을 보였으며 발육시기별로는 유충 보다는 성충이 높은 내한성을 나타냈다. 동계 기간 야외 조사는 시설재배지에서 진행되었다. 동계기간 동안 꽃노랑총채벌레 성충이 황색점착트랩, 잡초 그리고 토양에서 발견되었다. 고추에 일명 칼라병을 유발하는 TSWV 바이러스는 동계기간 일부 잡초에서 양성으로 나왔으나, 월동하는 꽃노랑총채벌레에서는 검출되지 않았다. 이상의 결과는 꽃노랑총채벌레가 시설재배지의 잡초 주변에서 월동이 가능하다는 것을 제시하며, 대만총채벌레의 경우는 번데기 휴면으로 월동할 것으로 추정된다.

검색어: 꽃노랑총채벌레, 대만총채벌레, 월동, 휴면, 체내빙결점

O31

Liquid culture for improving thermotolerance of *Beauveria bassiana* JEF-350 blastospores

Yu-jin Jeong[1], So-eun Park[1], Ye-ram Im[1], Insoo Jeon[1], Yu-lim Park[1], Ki-jung Kim[1], Ga-hyeon Song[1], Jong-cheol Kim[1] and Jae Su Kim[1, 2*]

[1]Department of Agricultural Biology, Jeonbuk National University, Korea
[2]Department of Agricultural Convergence Technology, Jeonbuk National University, Korea

Compared to solid culture, liquid culture reduces production time. However, blastospores are generally unstable to heat. In this study, *Beauveria bassiana* JEF-350 produced in different media were investigated to produce heat-resistant propagules. After liquid cultures of JEF-350 at SDB, SSYP, and YPG media for seven days, the productivity and thermotolerance were investigated. The blastospore productivity of JEF-350 was the highest in SSYP media. As a result of heat exposure to 45°C for 60 minutes, blastospores produced in SSYP-liquid medium showed the highest germination rate (22.6%). From a virulence test against *Thrips palmi*, the mortality of *T. palmi* on all treatments showed more than 95% in day 7 after fungal treatment. SSYP-liquid medium was considered as an excellent substrate to culture JEF-350.

Key words: *Beauveria bassiana*, culture media, thermotolrance, productivity, virulence

O32

Effect of repellency light on the *Grapholita molesta* (Busck)

Yong Ju Jang[1], Young Ha Woo[1] and Un Teak Lim[2]

[1]Agricultural corporation, Agricultural Management
[2]Department of Plant Medicals, Andong National University

환경독성을 유발하는 농약사용을 줄이기 위한 친환경 해충방제법의 하나로 횃불에서부터 LED까지 해충을 유살하기 위한 광원들이 개발되어 왔다. 일본에서는 여러 실험을 통해 야행성 곤충이 청색과 황색광 모두에서 명반응시간이 짧아져 방제에 효과적이라는 연구 결과가 보고되었고, 그 중에서 주로 590 nm파장의 황색광이 주로 사용되었다. 본 연구에서는 일본에서 개발된 황색광을 국내 과수원에서 적용하고자 실내외 평가를 실시하였다. 실내에서 복숭아순나방의 산란수가 황색광 처리구에서 48시간 후에 대조구에 비해 50%로 감소했다. 실외 사과과원에서는 복숭아순나방 피해가 유의하게 감소하는 것을 확인하였다, 따라서 황색등이 야행성 나방류 명적응 행동에 영향을 주어 해충유인성을 낮추는 방충등으로 적합하다고 판단하였다.

Key words: Repellent light, Oriental fruit moth, Aapple, 590nm

O33

Identification of entomopathogenic fungus *Metarhizium rileyi* and evaluation of its pathogenicity on fall armyworm, *Spodoptera frugiperda* larvae in Korea

Rajendra Acharya[1,2], Matabaro Joseph Malekera[1], Seung-Yeol Lee[1] and Kyeong-Yeoll Lee[1,3]
[1]Department of Applied Biosciences, Kyungpook National Ubiversity, Daegu, Korea
[2]Department of Entomology, HICAST, Purbanchal University, Nepal
[3]Institute of Plant Medicine, Kyungpook National University, Daegu, Korea

The fall armyworm (FAW), *Spodoptera frugiperda* is one of the important invasive pest in Africa and Asia. The chemical control of this pest is unsuccessful due to the development of resistant and harmful effects on the environment. In this study, the native strain of *Metarhizium rileyi* was identified using morphological and molecular characterization which was collected from the cornfield at Yeongcheon, Korea during August 2021. Susceptibility of fourth instar larvae of FAW to this native strain *M. rileyi* was examined in the laboratory. The results showed that the Korean strain of *M. rileyi* was highly pathogenic to FAW larvae, causing 89% mortality after 7 days post-treatment. Therefore, *M. rileyi* strain identified in this study could be used for biological control of FAW in the fields.

Key words: Fall armyworm, invasive pest, *Metarhizium rileyi*, mortality, biological control

O34

The potential of methyl benzoate as an insecticide: A critical evaluation against a variety of target arthropod pests

Md Munir Mostafiz[1], Ji-Youn Lee[2] and Kyeong-Yeoll Lee[1,2]
[1]Department of Applied Biosciences, Kyungpook National University, Daegu 41566, Korea
[2]Department of Agricultural management, Chilgok Agricultural Technology Center, Chilgok 39851, Korea
[2]Sustainable Agriculture Research Center, Kyungpook National University, Gunwi 39061, Korea

Biopesticides are biorational pesticides as they are less harmful to human health and the environment than synthetic pesticides. Methyl benzoate (MBe) is a relatively new botanical insecticide that occurs naturally as a metabolite in plants. In this study, we evaluated the insecticidal activity of MBe against a variety of insect pests. According to our laboratory findings, MBe has significant contact toxicity against cotton aphid and two-spotted spider mites, with an LC50 range of 1800 ppm to 3800 ppm. However, the LC50 values of MBe for *Aedes* and *Culex* mosquito species were found to be 61 and 185 ppm, respectively. Furthermore, MBe demonstrated strong fumigation toxicity against Indian meal moth and flat grain beetle with an LC50 value of 0.1 μL/L and 0.76 μL/1.5 L air, respectively. Additionally, MBe also has the ability to suppress acetylcholinesterase enzyme activity. Overall, MBe seems to be a highly promising candidate for the development of green insecticides that are more efficient, safe, and environmentally-friendly.

Key words: contact toxicity, fumigation toxicity, mode of action, naturally occurring compound, sustainable agriculture

O35

Inference of direct and indirect selection pressures for insecticide resistance development in *Anopheles* and *Culex* mosquitoes

Do Eun Lee[1], Ju Hyeon Kim[2] and Si Hyeock Lee[1,3]
[1]Department of Agricultural Biotechnology, Seoul National University
[2]Department of Tropical Medicine and Parasitology, Seoul National University
[3]Research Institute of Agriculture and Life Sciences, Seoul National University

Extensive use of synthetic insecticides, such as DDT, pyrethroids (PYRs), and organophosphates (OPs) for the control of medical pests, has resulted in high levels of resistance. Although only PYRs and some OPs are currently permitted as public health insecticides in South Korea, high levels of cyclodiene and OP resistance mutations have been observed in the field and thus it remains to be elucidated whether non-public health insecticides drive selection pressure against mosquito species. In this study, to test the hypothesis that agricultural insecticides can play a critical role in selection depending on mosquitoe's ecological habitat, resistance profiles to three insecticide groups (cyclodienes, PYRs and OPs) in two representative mosquito species (*Anopheles sinensis* and *Culex pipiens*) were investigated by analyzing the resistance allele frequencies of *rdl, kdr* and acetylcholinesterase 1 (*ace1*) G119S, respectively. After that, the correlation between the resistance allele frequency and the landuse status of 3-km radius of collection sites was analyzed. The *kdr* and *rdl* frequencies in *An. sinensis* showed negative correlation with forest area (r=-0.47 and r=-0.47 respectively), as forest is less likely to be exposed to insecticides. In the case of *Cx. pipiens*, the *kdr*, *rdl* and *ace1* mutations showed positive correlation with residential space (r=0.53), rice paddy (r=0.59) and field (r=0.87), respectively. Therefore, it can be inferred that PYRs used for public health function as the main direct resistance selection pressure, whereas agricultural insecticides such as fipronil and carbamates may work as indirect minor selection pressure.

Key words: *Anopheles sinensis*, *Culex pipens*, insecticide resistance, indirect selection, agricultural insecticides

O36

Use of entomopathogenic fungi to suppress *Spodoptera frugiperda* population

Insoo Jeon[1], So-Eun Park[1], Yeram Im[1], Yujin Jung[1], Yulim Park[1], Kijung Kim[1], Gahyeon Song[1], Jong Cheol Kim[1] and Jae Su Kim[1,2]
[1]Department of Agricultural Biology, Jeonbuk National University, Korea
[2]Department of Agricultural Convergence Technology, Jeonbuk National University, Korea

Fall armyworm, Spodoptera frugiperda is an invasive polyphagous pest derived from America. This pest has developed resistance to insecticides, such as pyrethroid, organophosphorus, and oxadiazine. Entomophatogenic fungi are alternative methods to control fall armyworm. Herein, virulence of entomophathogenic fungi against fall armyworm was screened. The productivity and thermotolerance of conidia were evaluated to figure out the potential for field application. Of the isolates, two isolates showed high virulence to pupae at soil treatment. Another two-isolate caused high mortality of larvae. These high virulence isolates would be promising biological control agents for the management of fall armyworm.

Key words: biological control, entomopathogenic fungi, Spodoptera frugiperda,

O37

Morphological and biological characteristics of *Lepgtoglossus occidentalis* Heidemann (Heteroptera: Coreidae) in Korea

Jae-Woo Lee[1], Minjung Huh[1], Il Nam[1], Ji-Hong Park[1], Dongho Lee[1], Minwoo Lee[1], Kyungjoo Hwang[1], Soungbin Cho[1] and Il-Kwon Park[1,2]

[1]Department of Agriculture, Forestry and Bioresources, Seoul National University
[2]Research Institute of Agriculture and Life Sciences, Seoul National University

The western conifer seed bug (WCSB), *Leptoglossus occidentalis* Heidemann is one of the most devastating pests in various conifers, which has caused significant decreases in seed production of seed orchards and pine nut plantations globally, especially *Pinus koraiensis* Siebold & Zucc. in central Korea since 2010. Herein, we investigated the morphological and biological characteristics of Korean WCSB population. The population showed relatively identical morphology with overseas populations. Body lengths of adult males and females were 17.2 and 19.05 mm, respectively, while pronotum widths were 4.85 and 5.55 mm, respectively. Body weights were 111.27 and 169.89 mg, respectively. Body lengths of the first to fifth instar nymphs were 3.07, 4.76, 8.77, 13.56, and 15.53 mm, respectively. Developmental duration of the eggs and nymphal instar stages were 8.63, 3.69, 7.63, 5.82, 5.83, and 9.15 days, respectively. Nymphal mortality was shown as 47.5%. Life expectancy of adult males and females were 58.2 and 63.9 days. A single Korean WCSB adult female laid averagely 68.6 eggs during the lifetime. Our results may contribute to understanding WCSB ecology and damage aspects in Korea.

Key words: *Leptoglossus occidentalis*, morphological characteristic, biological characteristics

O38

Response of fat body from Japanese pine sawyer beetle, *Monochamus alternatus* to the entomopathogenic fungus, *Beauveria bassiana* ERL836

Yulim Park[1], Soeun Park[1], Yeram Im[1], Insoo Jeon[1], Yujin Jeong[1], Kijung Kim[1], Gahyeon Song[1], Jong-Cheol Kim[1] and Jae Su Kim[1,2]

[1]Department of Agricultural Biology, Jeonbuk National University, Korea;
[2]Department of Agricultural Convergence Technology, Jeonbuk National University, Korea

Japanese pine sawyer beetle, *Monochamus alternatus*, is a vector of pine wilt nematode causing pine wilt disease. In this study, *Beauveria bassiana* ERL836, which showed high virulence against *M. alternatus* and the highest conidial thermostability was used to control *M. alternatus*. To investigate the response of fat body, we performed RNA-seq analysis of RNA samples obtained from fat body of *M. alternatus* in 2 and 4 days after ERL836 treatment. On day 2 and 4, genes involved in muscle contraction were upregulated, however, genes involved in defense response were downregulated.

검색어: *Monochamus alternatus*, transcriptome analysis, *Beauveria bassiana*, RNA-seq, biological control

O39

Selection of grain media for *Beauveria bassiana* 331R strain showing high acaricidal activity against *Tetranychus urticae*

Jin Yong Lee, Ra mi Woo, Thida Win, Hyun Soo Kim and Soo Dong Woo
Department of Agricultural Biology, College of Agriculture, Life & Environment Science, Chungbuk National University, Cheougju 28644, Korea

점박이응애는 200여개의 과수와 채소, 관상식물들을 가해하는 주요 해충으로 무분별한 살충제 사용에 따른 천적제거와 빠른 저항성발달로 방제가 어려운 실정이다. 이를 방제하기 위해 높은 살비력을 보이는 곤충병원성 곰팡이 *Beauveria bassiana* 331을 대량생산 할 수 있는 배지를 선발하고자 하였다. 각 곡물에서 생산된 conidia의 살비력, 포자생산량, 환경안정성을 평가한 결과 기장과 쌀에서 높은 살충활성과 생산효율을 보였으며, 특히 쌀 배지에서 상대적으로 높은 열과 UV-B에 대한 안정성이 확인되었다. 쌀 배지가 *B. bassiana* 331R균주에 최적배지로 결정되었고, 추후 제제화 후 활성에 대한 연구를 진행하고자 한다.

검색어: 곤충병원성곰팡이, *Beauveria bassiana*, 점박이응애, 곡물배지

O40

Bioassay and genotyping based Diamide resistant status of Korean populations of *Spodoptera exigua* (Lepidoptera: Noctuidae)

Chang Hee Han[1], Hwa Yeun Nam[2] and Juil Kim[1,2]
[1]Program of Applied Biology, Division of Bio-resource Sciences, CALS, Kangwon National University
[2]Agriculture and Life Science Research Institute, Kangwon National University

Beet armyworm, *Spodoptera exigua*, is one of the most destructive polyphagous lepidopteran pests worldwide including in Korea. To control *S. exigua*, diamides have been widely used for more than a decade. Since 2017, a high level of diamide resistance has been reported up to now. Bioassay-based diamide resistance was tested field populations of *S. exigua* for some years. The level of diamide resistance varied with tested year and region. Known three point mutations such as Y4701, I4790, and G4946 in RyR which target site of diamide was surveyed. Among them, only I4790 mutation was detected in most field populations. Moreover, insecticide-resistant population-specific intronic InDels and SNPs were also identified. This genetic diversity possibly generates different levels of diamide resistance in Korea. Therefore, population genetics-based insecticide resistance management (IRM) strategy has to prepare for diamide resistant population of *S. exigua*. A genetic marker-based diagnostic tool such as LAMP was developed and applied in the IRM of *S. exigua*.

Key words: *Spodoptera exigua*, diamide, I4760 mutation, InDel

Small Group Meeting

S1

Promoter exchange of NRPS gene cluster in entomopathogenic bacteria *Xenorhabdus hominickii* and *Photorhabdus temperata*

Il-Hwan Kim
Division of Chemical and Biological Metrology, Korea Research Institute of Standards and Science

곤충병원성 미생물인 *Xenorhabdus* 와 *Photorhabdus*는 비리보좀 펩타이드 합성효소(Non-ribosomal peptides synthetase, NRPS)를 통해 곤충병원성 이차대사산물을 생산한다. 그 중, 펩타이드 계열 곤충 생리교란 기능물질인 GameXPeptide(GxpS)은 고리모양의 뎁시펩타이드이며, *Xenorhabdus hominickii*와 *Photorhabdus temperata*를 포함한 다양한 *Xenorhabdus*와 *Photorhabus* 속에서 발현된다. NRPS 유래 이차대사산물 발현량 증가를 위한 방법의 하나로 프로모터 교환기술이 이용된다. *Xenorhabdus hominickii*와 *Photorhabdus temperata*의 GxpS 발현 NRPS 유전자 클러스터의 프로모터를 pBAD와 같은 유도프로모터로 교환하여 GxpS 발현량 증가를 유발하며, GxpS 전사체와 대사체 변화량을 디지털 PCR과 엑체크로마토그래피 시스템을 이용해 측정한다.

검색어: 곤충병원성 미생물, 유전자 공학, 이차대사산물, 비리보좀 펩타이드 합성효소

S2

IBC microbial agent formulation technique development

Yeo Jun Yoon, Su Jin Kim, Min Hyun Kim and Je Kyung Park
Koreabio Co., LTd.

IBC(Intergated Biological Control) 미생물 작물보호제 개발을 위해 *Xenorhadus*속, *Photorhabdus*속 미생물과 *Bacillus thuringiensis*, *Beauveria bassiana*, *Metarhizium rileyi*을 조합하여 미생물의 단점을 보완하고 장점을 극대화하기 위한 제형화 및 제제화 기술을 개발하였다. 대파에 발생하는 주요 해충에 대한 실내 살충효과 검정을 통해 IBC 미생물의 제품 투입비율을 결정하였고, 액상수화제용 시제품은 *Xenorhadus*속, *Photorhabdus*속 미생물 동결건조물과 *B. thuringienis* 배양액 또는 *B. bassiana*, *M. rileyi* 배양물을 각각 조합하고 제제화용 보조제를 혼합하여 제작하였으며, 수화제용 시제품은 *Xenorhadus*속, *Photorhabdus*속 미생물 동결건조물과 *B. thuringienis* 동결건조물 또는 *B. bassiana*, *M. rileyi* 배양물을 각각 조합하고 제제화용 보조제를 혼합하여 제작하였다. 제작된 시제품을 –4℃, 25℃, 50℃에서 보관하며 경시적 안정성을 확인한 결과 액상수화제용 시제품은 50℃에서 4주차부터 저장안정성이 유지되지 않았으며, 수화제용 시제품은 온도에 상관없이 10주 이상 저장안정성이 유지되었다. 상기의 결과를 토대로 최종 시제품의 제형은 수화제로 결정하고 IBC 미생물제 시제품의 생산공정을 확립하였다.

검색어: 미생물, 친환경, 작물보호제, 살충제, 제형화

S3

Integrated biological control and new microbial insecticides

Yonggyun Kim
Department of Plant Medicals, Andong National University

Xenorhabdus and *Photorhabdus* are two bacterial genera specifically symbiotic to *Steinernema* and *Heterorhabditis,* which are the entomopathogenic nematode genera, respectively. These bacteria are well known to produce potent secondary metabolites suppressing insect immune responses. This study aimed to develop a high efficient microbial insecticide against the onion thrips, *Thrips tabaci*, using the bacterial metabolites. Among the chemical insecticides that have been used to control the thrips, spinosad was highly effective against both larvae and adults of *T. tabaci*. Three different entomopathogenic fungi were also effective to kill the thrips at both developmental stage. However, the fungal virulence was much less than the control efficacy of the chemical insecticide, spinosad. To enhance the fungal virulence, the bacterial culture broth of *Xenorhabdus*/*Photorhabdus* was added in order to suppress the thrips' immune defense. Among six different bacterial species, *X. hominickii* produced highly potent metabolites to enhance the fungal virulence. Indeed, four different bacterial metabolites (GameXPetide, benzylideneacetone, oxindole, and 3-ethoxy-4-methoxyphenol) of the bacteria suppressed the gene expressions of three different antimicrobial peptides (cecropin, defensin, and gallerimycin). To optimize the mixture ratio of fungal and bacterial pathogens, the fungal spores and bacterial culture broth were freeze-dried and mixed in different ratios. Laboratory and field assays showed that 1:3 (fungal: bacterial) mixture ratio was turned out to be the most virulent against *T. tabaci*.

Key words: *Xenorhabdus*, *Photorhabdus*, *Beauveria bassiana*, Thrips tabaci, Immunity

Poster Presentation

P1

Newly recorded insects from Ulleungdo, Korea

Jae Won Choi[1,2], Min Hyeok Won[1,2], Dong Yeol Lee[1], Woo Jun Bang[1], Min ki Moon[1], Young-Kun Kim[3] and Kwang Shik Choi[1,2,4]

[1]School of Life Sciences, College of Natural Science, Kyungpook National University, Daegu, Korea
[2]Research Institute for Dok-do and Ulleung-do Island, Kyungpook National University, Daegu, Korea
[3]School of Applied Biosciences, College of Agiculture & Life Science, Kyungpook National University, Daegu, Korea
[4]Research Institute for Phylogenomics and Evolution, Kyungpook National University, Daegu, Korea

울릉도는 육지와 한 번도 연결된 적 없는 대양섬으로, 해양성 기후로 인하여 여름엔 서늘하고 겨울엔 온난하기 때문에 남방계 식물과 북방계 식물이 함께 자생하고 있다. 이러한 독특한 생태적 특성으로 인하여 울릉도는 내륙의 곤충상과 차이를 보인다. 첫 조사가 이루어진 1955부터 2012년까지 울릉도에는 총 18목 179과 1,177종이 기록되어 있으나, 도서지역의 까다로운 접근성으로 인하여 그동안 활발한 조사가 이루어지지 않았다. 이에 본 연구는 2020년 4월부터 10월까지 울릉도 성인봉에서 4차례 곤충상 조사를 하였으며 등화채집, 쓸어잡기, 당밀유인채집, 함정채집 네 가지 방법으로 채집을 진행하였다. 채집결과 울릉도에 미기록된 1목 16과 2아과 16속 78종이 새로 발견되었다. 울릉도에는 아직 발견되지 못한 미기록종이 더 있을 것으로 예상되며, 본 연구 결과는 향후 이루어질 울릉도 전체의 곤충상 조사에 활용될 수 있을 것으로 기대된다.

검색어: Ullengdo, Seonginbong, insect fauna, unrecorded species

P2

The introduction of a non-native order Embioptera to Korea via ornamental plants

Do-yoon Kim[1], Wonjun Sung[2], Yeong hun Kim[2] and Seunggwan Shin[1]

[1]School of Biological Sciences, Seoul National University, Seoul, 08826, South Korea
[2]Choongal farm, Seoul, 08555, South Korea

This study reports a webspinner, *Aposthonia ceylonica*, found in imported ornamental *Tillandsia* plants in greenhouse gardens in Paju and Seoul. This is the second record of a non-native Embioptera in Korea. The insects were found in the gaps between the basal leaves of the plants, and lived as a group in galleries of woven silk produced from the forelegs. The morphological characters and silk structures were investigated using scanning electron microscopy. The mitochondrial *COI* gene was sequenced for molecular identification, and to evaluate the validity of DNA barcoding for Embioptera. These insects can only survive and breed in greenhouse gardens because they are subtropical to tropical. However, they might ultimately settle after introduction in the Korean Peninsula if tropicalization continues.

Key words: Webspinner, Invasive species, *Aposthonia ceylonica*, Silk, Greenhouse

P3

Wing morphological analysis of *Culex pipiens* complex using geometric morphometric

Jiseung Jeon[1,2], Dong Yeol Lee[1], Ye Won Cho[1] and Kwang Shik Choi[1,2,3]

[1]School of Life Sciences, College of Natural Sciences, Kyungpook National University, Daegu, Korea
[2]Research Institude for Dok-do and Ulleng-do Island, Kyungpook National University, Daegu, Korea
[3]Research Institude for Phylogenomics and Evolution, Kyungpook National University, Daegu, Korea

현재 국내의 *Culex pipiens* complex 중에서 *Culex pipiens pallens*와 *Culex pipiens molestus*는 형태적 분류의 어려움 때문에 아종 단계까지 분류가 잘 이루어지지 않고 있다. 이에 본 연구에서는 기존의 형태학적 분류 방법을 보완하고자 Geometric Morphometric(GM)을 국내에 서식 중인 *Culex pipiens* complex의 암컷 성체의 날개에 적용하였다. 2021년 6월부터 9월까지 전국 9개 지역에서 모기 채집을 진행하였으며, 우선적으로 분자마커를 이용해 *Cx. p. pallens*와 *Cx. p. molestus*를 분류해냈다. 또한 비교를 위한 외집단으로 *Aedes albopictus*를 추가적으로 채집하여 함께 비교하였다. 분석 결과, *Culex pipiens* complex의 두 모기 아종과 *Ae. albopictus*의 경우 날개의 형태적 차이가 명확하게 나타났으며 (Mahalanobis distance=13.9978), 근연관계인 *Cx. p. molestus*와 *Cx. p. pallens*의 경우에도 명백하게 차이가 있음이 나타났다 (Mahalanobis distance=4.9523). 본 연구에서 GM을 이용하여 *Culex pipiens* complex의 두 아종을 성공적으로 분류해 냈으며, 형태적으로 구분이 어려운 다른 모기종에도 GM을 이용한 분류가 적용 가능할 것으로 기대된다.

검색어: Geometric Morphometric, Culex pipiens complex, Culex pipiens pallens, Culex pipiens molestus

P4

A new record of the genus *Orthotylus* Fieber (Heteroptera: Miridae) in Korean Peninsula, with a discussion on intraspecific variation of some orthotyline species

Minsuk Oh[1,2] and Seunghwan Lee[1,2]

[1]Laboratory of Insect Biosystematics, Department of Agricultural Biotechnology, Seoul National University
[2]Research Institute of Agriculture and Life Sciences, Seoul National University

Orthotylus is the largest genus among Orthotylinae, including around 300 species. In this work, we recognized seven species of Orthotylus in Korea, including *O. riparius* Kulik which previously was known only from the Russian Far East. Keys to the Korean *Orthotylus* is provided. Additionally, Distributional records of *Orthotylus riparius* and *O. salicis* in East Asia are briefly discussed, with an emphasis on subsequent misidentifications in recent works and observed variant.

Key words: Hemiptera, Miridae, Orthotylini, Orthotylus, the Korean peninsula, new record

P5

Four new records of the subfamily Acaenitinae from South Korea

Gyu-Won Kang[1] and Jin-Kyung Choi[2]
[1]Insect Inquiry Education Institute, Daegu National University of Education
[2]Department of Science Education, Daegu National University of Education

The subfamily Acaenitinae are one of the family Ichneumonidae, currently 280 species in 28 genera worldwide. In Korea 16 species in six genera have been recorded. The Pimplinae group are mainly koinobiont, endoparasitiods of Coleoptera, Lepidoptera. In this study, we report four species (*Jezarotes levis* Sheng, *Yezoceryx rishiriensis* Uchida, *Coleocentrus lineacus* Sheng & Shen and *Mesoclistus atuberculatus* Wang) of Acaenitinae for the first time from South Korea. Which of them, two genera (*Yezoceryx and Mesoclistus*) are also newly recorded from South Korea. Photographs of habitus and diagnoses of newly recorded species are provided.

Key words: Taxonomy, parasitic wasps, unrecorded species, eastern palaearctic region

P6

A new records of the genera *Cissidium* and *Ptinella* with one additional species of the genus *Baeocrara* (Coleoptera: Ptiliidae) from South Korea

Taeyoung Jang and Jong-Seok Park
Department of Biological Sciences and Biotechnology, Chungbuk National University, Korea

The family Ptiliidae is readily collected from sifting leaf litter, decaying wood, mammal dung and fungi, and distinguished from other coleopteran families based on minute body size (less than 2 mm), feather-like hindwings and peculiar setae on antennomeres. Ptiliids are one of the poorly known beetles groups in Korea. Approximately 850 valid ptiliid species are known worldwide, 70 species have been recorded in Japan and Russian Far East. However, in Korea, taxonomic studies involving ptiliid beetles were started with the recording of three species *Acrotrichis lewisii*, *Baeocrara variolosa* and *Dipentium japonicum* in 2020–2021. In this study, three additional ptiliid species, *Baeocrara japonica*, *Cissidium elongatum* and *Ptinella mekura* are recorded in Korea for the first time.

Key words: *Baeocrara*; *Cissidium*; *Ptinella*; featherwing beetle; taxonomy.

P7

First record of the cockroach *Margattea* Shelford (Blattodea: Ectobiidae) in Korea

Jaeil Shim and Jeong-Hun Song
Department of Agricultural Biology, National Institute of Agricultural Sciences

The small sized cockroach genus *Margattea* Shelford is reported for the first time in the Korean Peninsula. They were collected at sites on some southern islands including Jeju island, Korea. Habitus photographs and diagnostic characters of *Margattea nimbata nimbata* (Shelford) and a key to the genera of Korean Ectobiidae are provided to facilitate identification.

Key words: Cockroach, Ectobiidae, *Margattea*, *Margattea nimbata nimbata*, new record

P8

A new record of the bothriderid genus *Ascetoderes* Pope (Coleoptera: Coccinelloidea) from South Korea

Jongok Lim[1], Jong-Kook Jung[2] and Sora Kim[3]
[1]Department of Life and Environmental Sciences, Wonkwang University
[2]Department of Forest Environment Protection, Kangwon National University
[3]Department of Plant Protection & Quarantine, Jeonbuk National University

The Bothrideridae (Coleoptera: Coccinellioidea) is called as ‘cocoon-forming beetles’ or ‘dry dark beetles’ and this family includes about 400 species in 38 genera worldwide and just two species of two genera belonging to the family have been recorded the Korean peninsula. It is known that most bothriderids are associated with wood-boring insects and are known as fungal feeders or ectoparasites of wood-boring immature insects in many studies. As a results of taxonomic study on Korean Bothrideridae, the genus *Ascetoderes* Pope is discovered based on *A. takeii* (Nakane, 1967) from Korea for the first time. In this presentation, *A. takeii* (Nakane) is re-described with illustrations of diagnostic characteristics in detail, as well as, a key to Korean Bothrideridae is provided.

Key words: *Ascetoderes takeii* (Nakane), Bothrideridae, Coccinellioidea, new record, South Korea

P9

A new record of *Stenochinus* Motchulsky (Coleoptera: Tenebrionidae) from South Korea

Jongok Lim[1], Seung-Jin Roh[2], Dong-June Lee[2] and Yeong-Eun Han[3]
[1]Department of Life and Environmental Sciences, Wonkwang University
[2]Department of Island and Coast Biodiversity, Honam National Institute of Biological Resources
[3]Research Institute of Forest Insect Diversity

Within the order Coleoptera, Tenebrionidae is one of most diverse taxon and it is the largest family in Tenebrionoidea. The adults and larvae of tenebrionids live in diverse habitats and they live in rotten wood, stored agricultural products, soil, leaf litter and so on. As a result of taxonomic study on Korean Bothrideridae, the genus *Stenochinus* Motschulsky is newly discovered from several localities in Jeonnam province, Republic of Korea. In the present paper, we re-described *Stenochinus bacillus bacillus* (Marseul, 1876) with a plate on diagnostic characteristics.

Key words: *Stenochinus bacillus* (Marseul), Tenebrionidae, new record, Republic of Korea, taxonomy

P10

A newly recorded genus *Discodes* Förster, 1856 (Hymenoptera: Chalcidoidea: Encyrtidae) from Korea

Subin Choi[1] and Sunghoon Jung[2]
[1]Laboratory of Systematic Entomology, Department of Applied Biology, College of Agriculture and Life Sciences, Chungnam National University
[2]Department of Smart Agriculture Systems, Chungnam National University

The genus *Discodes* Förster are distributed mainly in the southern regions of Palearctic regions. In the neighboring countries, three species in China, eight species in Russia are recorded. Most of the *Discodes* species are primary parasitoids of species of the Coccidae family. Some attack coccoids of the families Asterolecaniidae, Eriococcidae, and Pseudococcidae. In this study, the genus Discodes is reported for the first time from Korea with a newly recorded species. The diagnosis and photographs of the specie are presented.

Key words: *Discodes*, Encyrtinae, Hymenoptera, Korea, New record, parasitic wasp

P11

Taxonomic study of the genus *Eupteryx* Curtis (Hemiptera: Auchenorrhyncha: Cicadellidae: Typhlocybinae) with one new species from Korea

Sumin Oh[1] and Sunghoon Jung[1,2]
[1]Department of Applied Biology, Chungnam National University, Korea
[2]Department of Smart Agriculture Systems, Chungnam National University, Korea

The genus *Eupteryx* was established by Curtis, 1829 with *Cicada atropunctaca* Goeze as its type species. This genus belongs to the tribe Typhlocybini. Some species were known as important pest of plants in the mint family. In Korea, three species have been recorded; *E. melanocephala*, *E. minuscula*, *E. undomarginata*. In this study, we provide a taxonomic review of the genus *Eupteryx* from Korea with a new species.

Key words: leafhopper, taxonomy, key, pest

P12

A new record of the genus *Kolla* (Hemiptera: Auchenorrhyncha: Cicadellidae: Cicadellinae) from Korea, with DNA barcoding data

Munirah Hamzah[1] and Sunghoon Jung[1,2]
[1]Department of Applied Biology, Chungnam National University, Korea
[2]Department of Smart Agriculture Systems, Chungnam National University, Korea

Genus *Kolla* Distant, 1908 belongs to the tribe Cicadellini under the subfamily of Cicadellinae (Hemiptera: Auchenorrhyncha: Cicadellidae). In the world, 40 species have been recorded. While in Korea, only one species, *Kolla atramentaria* has been recorded. Some species of this genus are economically important pest that play a role as vectors of *Xylella* disease. In this study, we provide a description, illustration, and DNA barcodes of one newly recorded species of genus *Kolla* from Korea.

Key words: Cicadellinae, new record, taxonomy, *Kolla*, DNA barcodes

P13

Review of the Korean species of the genus *Edaphus* Motschulsky (Coleoptera, Staphylinidae) with description of four new species.

Ui Joung Byeon[1], Sun Jae Park[2], Seung Gyu Lee[2] and Jong Seok Park[1]
[1]Department of Biological Sciences and Biotechnology, Chungbuk National University, Korea
[2]Animal Resources Division, National Institute of Biological Resources, Korea

The Euaesthetinae genus, *Edaphus* Motschulsky, 1857 comprises approximately 600 species worldwide and about ninety species were known from Palearctic regions. A single species of *E. koreanus* Puthz, 2011 has been documented from the southern part of the Korean Peninsula. Four new species, *Edaphus* sp.1 **sp.n.**, *E.* sp.2 **sp.n.**, *E.* sp.3 **sp.n.** and *E.* sp.4 **sp.n.** are described and *E. koreanus* and *E. lederi*, are redescribed, and the latter species is recorded from Korea for the first time.

Key words: soil arthropod, sifting method, leaf litter, palaearctic

P14

Description of a new species of *Monoblastus* (Hymenoptera: Ichneumonidae: Tryphoninae) from South Korea

Jin-Kyung Choi[1] and Jong-Wook Lee[2]
[1]Department of Science Education, Daegu National University of Education
[2]Georim Entomological Institute

A new species of the genus *Monoblastus*, belonging to the subfamily Tryphoninae, family Ichneumonidae, is described in Korea. The subfamily Tryphoninae was recorded by Shuckard in 1840 based on genus *Tryphon* and more than 1,290 described species into 57 genera in seven tribes have been reported worldwide. Among the 57 genera of Tryphoninae, genus *Monoblastus* belonging to the tribe Tryphonini, which was recorded 30 species worldwide. Half of this genus occur in the Nearctic and 13 species have been reporded in the Palaearctic. The aim of this study is to describe a new species from South Korea and provide a key to species South Korean *Monoblastus*.

Key words: *forsythia,* new species, parasitoids, taxonomy

P15

A new species of the genus *Andricus* Hartig, 1840 (Hymenoptera: Cynipidae: Cynipini) from South Korea

Minjoon Kang[1,2] and Sunghoon Jung[1,2]
[1]Laboratory of Systematic Entomology, Department of Applied Biology, Chungnam National University
[2]Department of Smart Agriculture Systems, Chungnam National University

A new species of the genus *Andricus* Hartig, 1840 is described from South Korea. This species is known only from sexual generation and induces galls on leaf of *Quercus mongolica*. Data on the diagnosis, description and biology are given for new species.

Key words: Hymenoptera, Cynipidae, new species, *Andricus*, South Korea

P16

First record of *Acleris tigricolor* (Lepidoptera: Tortricidae: Tortricinae) from Korea

Hye-Min Byun[1,2], UnHong Heo[3] and Sunghoon Jung[1,2]
[1]Department of Smart Agriculture Systems, Chungnam National University
[2]Laboratory of Systematic Entomology, Department of Applied Biology, Chungnam National University
[3]Godeok Lotte Castle Venerouche

The family Tortricidae is a large group comprising 10,350 described species in the world. Among them, the genus *Acleris* Hübner contains 261 species worldwide and 45 species are recorded in Korea. In this study, *Acleris tigricolor* Walsingham (Tortricidae: Tortricinae: Tortricini) is reported for the first time from Korea. Distributions, redescription and illustrations of the specimens including the wing pattern, genitalic structures of male, and information of host plant are provided.

Key words: Leaf roller moth, Tortricini

P17

A new record of the genus *Euderus* Haliday (Hymenoptera: Chalcidoidea: Eulophidae) from Korea

Jongmin Bae[1,2] and Sunghoon Jung[1,2]
[1]Laboratory of Systematic Entomology, Department of Applied Biology, Chungnam National University
[2]Department of Smart Agriculture Systems, Chungnam National Universituy

The genus *Euderus* Haliday is a cosmopolitan genus with 80 described species. Until the present, only one species of the genus has been reported from Korea. In this presentation, we report a new record of the genus *Euderus* from Korea, with its figures.

Key words: taxonomy, parasitoid, Entiinae, the Korean Peninsula

P18

A taxonomic study on *Zimmermannia* Hering (Lepidoptera: Nepticuloidea: Nepticulidae), a newly recognized genus with three unrecorded species in South Korea

Young-Min Shin, Il-Kwon Kim and Bong-Woo Lee
Division of Forest Biodiversity, Korea National Arboretum

The genus *Zimmermannia* Hering (Lepidoptera: Nepticulidae) comprises 17 valid species worldwide. Its members are known to be bark-miners on various plant species in Fagaceae and *Ulmus* in Ulmaceae. They are distributed in the Palaearctic and Nearctic regions. In the eastern Asia, there are four species known from Russia, two species from Japan and one species from China. Up to date, there was no species reported from the Korean peninsula. In this study we make the first report on the genus from South Korea with three newly recognized species: *Z. admiranda* Puplesis, *Z. amani* Svensson and *Z. sivickisi* Puplesis. The newly recorded species are presented with diagnoses and the images and genitalia of the adults. In addition, an identification key to the Korean species is provided.

Key words: Lepidoptera, Nepticulidae, *Zimmermannia*, newly record, Korea

P19

Preliminary result of a taxonomic study on Odiniidae (Diptera: Opomyzoidea), a newly recognized family to South Korean insect fauna

Jeong-Hwan Choi, Seung-Su Euo and Il-Kwon Kim
Division of Forest Biodiversity, Korea National Arboretum, Pocheon, Republic of Korea

Odiniidae is a small family with 76 known species in 18 genera worldwide. The family is currntly divided into two subfamilies, namely Traginopinae and Odiniinae. The first one includes *Traginops* and *Schildomyia*, currently recognized by the present study, in South Korea. *Traginops* is recorded not only in the Palaearctic region including East Asia such as China and Japan, but also in the Afrotropical, Oriental, and Nearctic region. Most species of *Schildomyia* are known from the Neotropical region, and only two species, *S. yushimai* and *S. chinganensis*, were recorded in Japan and Russian Far East. As a result of our taxonomic study of the South Korean Odiniidae, we recognized two species, *Traginops naganensis* and *Schildomyia chinganensis*, using morphological characters. In the present study, we provide taxonomic information on the family and genera, and diagnoses of the two species along with the images of habitus and diagnostic characters.

Key words: Diptera, Opomyzoidea, Odiniidae, *Traginops*, *Schildomyia*, sap-feeding

P20

Wrong marriage and its consequence: mismatches in three *Pholcus* species (Araneae: Pholcidae) from Korea

Jun-Gi Lee[1], Jun-Ho Lee[1], Sun-Jae Park[2], Min-Jeong Baek[2] and Sam-Kyu Kim[1]
[1]Applied Biology Program, Division of Bio-resource Sciences, Kangwon National University
[2]Animal Resources Division, National Institute of Biological Resources

The genus *Pholcus* Walckenaer is the largest group of the cellar spider family (Araneae: Pholcidae), consisting of 21 species-groups. Since members of same species-group share very similar somatic morphology and species sympatry is often observed, mismatches of both sexes can be occurred in this genus. In this study, male and female of three species belonging to *Pholcus phungiformes*-group, *viz*, *Pholcus crassus* Paik, *Pholcus montanus* Paik and *Pholcus yeongwol* Huber were found to be mismatched, judging from comparison of type series, recent field data, and copulatory organ morphology. Brief descriptions with photographs of the "correctly coupled" male and female of these species are provided.

Key words: cellar spiders, mismatch, *Pholcus*, *phungiformes*-group, taxonomy

P21

Four newly recorded genera of the *Hypocera*-group (Diptera: Phoridae) from South Korea

Jun-Ho Lee[1] and Sam-Kyu Kim[2]
[1]Applied Biology Program, Division of Bio-resource Sciences, Kangwon National University
[2]Interdisciplinary Program in Smart Agriculture, College of Agriculture & Life Sciences, Kangwon National University

Hypocera-group is a monophyletic group of large and robust scuttle flies within the subfamily Phorinae (Diptera: Phoridae), consisting of 10 genera. Although the species diversity of this group in adjacent countries of Korea has been well-revised, no attention has been given to this taxon in Korea. In this study, four genera of the *Hypocera*-group, *viz.*, *Borophaga*, *Hypocera*, *Peromitra*, and *Stichillus*, are newly recorded from South Korea. These genera can be easily identified based on following characteristics: morphology of vertex, wing venation, tibial chaetotaxy, and male hypopygium. Brief diagnoses with photographs and a key to all phorid genera including four newly recorded genera in South Korea are provided.

Key words: *Borophaga*, *Hypocera*, *Peromitra*, scuttle flies, *Stichillus*, taxonomy

P22

New generic records of the two minute vampires, the biting midges (Diptera: Ceratopogonidae) and sand flies (Diptera: Psychodidae) from Korea

Jun-Ho Lee[1], Sangwoo Kim[1], Jun-Gi Lee[1] and Sam-Kyu Kim[2]
[1]Applied Biology Program, Division of Bio-resource Sciences, Kangwon National University
[2]Interdisciplinary Program in Smart Agriculture, College of Agriculture & Life Sciences, Kangwon National University

The family Ceratopogonidae and the subfamily Phlebotominae are groups of small to minute hematophagous flies and are well-known as vectors of various zoonoses. Despite of their hygienic importance, little attention has given to the diversity of biting midges in Korea for decades except for the genus *Culicoides*, and sand flies have never been studied in Korea. A preliminary study on biting midges and sand flies in Korea is conducted based on the specimens collected by malaise traps from several locations in South Korea. As a result, three genera of Ceratopogonidae, *viz.*, *Alluaudomyia*, *Forcipomyia*, and *Palpomyia*, and a phlebotomine genus *Sergentomyia* are recorded newly in South Korea. Brief diagnoses with photographs of four newly recorded genera are provided.

Key words: Ceratopogonidae, hematophagous flies, Korea, Phebotominae, taxonomy

P23

A new anophthalmic species of the genus *Galloisiana* (Grylloblattodea, Grylloblattidae)

Jangwon Seo and Jong-Seok Park
Department of Biological Sciences and Biotechnology, Chungbuk National University

The Genus *Galloisiana* Caudell & King 1924, comprises 14 species distributed in China, Japan, Korea and Russia. There are four species recorded in Korea currently. Here we report additional new species from Gwangyang-si, Jeollanam-do, Korea. This species can be distinguished from other *Galloisiana* species by following features: pronotum long as wide, eye absent and distinguishable shape of genitalia, especially broad basal part of principal copulatory sclerite. Illustrations of habitus, diagnostic characters are also provided.

Key words: Grylloblattodea, Korea, Notoptera, new species

P24

First record of the genus *Clusiodes* Coquillett (Diptera: Clusiidae) in Korea

Jonghwan Choi, Do-yoon Kim and Seunggwan Shin
School of Biological Sciences, Seoul National University

Clusiidae (Diptera: Schizophora) is a diverse family of saproxylic flies with over 600 species in 13 genera distributed worldwide. The family has received little attention in Korea, with only two species recorded up to date. In this study the genus *Clusiodes* Coquillett is reported from Korea for the first time, with one newly recorded species, *C. flaveolus* Mamaev. Morphological diagnosis is provided with figures of the body, wing, and male genitalia. The specimen examined is also genetically distinguished from congeners by the mitochondrial cytochrome c oxidase I gene (COI) sequence, hereby presented as the first DNA barcode for the species.

Key words: Clusiidae, *Clusiodes*, *C. flaveolus,* DNA barcode, new record

P25

The subfamily Beaninae Zahiri & Holloway, 2013 (Lepidoptera: Nolidae) newly recorded in Laos

Yeong-Bin Cha[1] and Yang-Seop Bae[1,2]

[1]Division of Life Sciences, College of Life Sciences and Bioengineering, Incheon National University, Academi–ro, Incheon 22012, South Korea.

[2]Bio–Resource and Environmental Center, Incheon National University, Academi–ro, Incheon 22012, South Korea.

The subfamily Beaninae Zahiri & Holloway is newly reported in Laos with a species, *Beana* sp.1. Taxonomic account and brief description presented. Illustrations of both sexes of adults and genitalia of all examined species are provided.

Key words: Oriental region, Laos, new record, Beaninae, *Beana*

P26

Key to genera of the Epipaschiinae (Lepidoptera, Pyralidae) in Korea based on the wing venation

Hanul Kim[1], Ulziijargal Bayarsaikhan[2], Tak-Gi Lee[1], Yeong-Bin Cha[1], Chang-Moon Jang[1], Jung-Nam Kim[1] and Yang-Seop Bae[1,2]

[1]Division of Life Sciences, College of Life Sciences and Bioengineering, Incheon National University

[2]Bio-Resource and Environmental Center, Incheon National University

The subfamily Epipaschiinae is belonging to the family Pyralidae, in the superfamily Pyraloidea. Moths of the epipaschiine are normally medium-sized, approximately 705 species have been described worldwide, mostly distributed in Tropical and Temperate Regions (Nuss *et al*., 2022). In this study, we present the key to genera of the Epipaschiinae in Korea based on the wing venation. Additionally, we provide illustrations of wing venation, all known genera of the Epipaschiinae in Korea.

Key words: Pyraloidea, Pyralidae, wing vein, taxonomy, Korea

P27

Checklist of genus *Olethreutes* (Lepidoptera: Tortricidae: Olethreutinae) from South Korea

Jeong-Nam Kim[1], Ulziijargal Bayarsaikhan[2], Tak-Gi Lee[1], Yeong-Bin Cha[1], Chang-Moon Jang[1], Hanul Kim[1] and Yang-Seop Bae[2]

[1]Division of Life Sciences, College of Life Sciences and Bioengineering, Incheon National University, Academi-ro, Incheon, 22012, South Korea

[2]Bio–Resource and Environmental Center, Incheon National University, Academi–ro, Incheon 22012, South Korea

The genus *Olethreutes* was established by Hübner (1822) based on the type species *Phalaena arcuella* Clerk. This genus reported 230 species about in the worldwide.

Up to date, 20 species of *Olethreutes* have been reported in South Korea. In this study, we provide checklist and illustrations of adult of *Olethreutes* from South Korea.

Key words: Tortricoidea, distribution, Palearctic Region, Taxonony

P28

DNA barcoding of the 52 species of family Tortricidae (Lepidoptera) in Korea

Jin-Sung Kweon[1], Bong-Woo Lee[2], Il-Kwon Kim[2] and Bong-Kyu Byun[1]

[1]Department of Biological Science and Biotechnology, Hannam University, Daejeon, Korea

[2]Korea National Arboretum, Pocheon, Korea

The family Tortricidae, so called as leaf-rollers, have been known as a difficult group in identification due to their small size and similar wing patterns among the allied species. Some species are well known as pests to the agricultural and ornamental plants that occur abundantly enough to cause injuries to plants of economic importance. Therefore, this study was carried out to provide the DNA barcode and related information for distinguish the complex species on tortricids group. In this study, we obtained and analyzed the DNA barcodes from 191 specimens of 52 species in the family Tortricidae. Among them, we obtained 162 specimens of 44 species in the subfamily Olethreutinae and 29 specimens of 8 species in the subfamily Tortricinae, respectively. Based on the result, two species of the genus *Cydia* and *Rhyacionia* area reported for the first time from Korea. Detected unrecorded species groups will be determine by further study including intensive taxonomic review in near future.

Key words: Lepidoptera, Tortricidae, Olethreutinae, DNA barcode, identification

P29

Taxonomic clarification of *Tebenna micalis* (Mann, 1857) named as *Tebenna issikii* (Matsumura, 1931) (Lepidoptera: Choreutidae) in Korea

Sang-Yoon Kim and Bong-Kyu Byun
Department of Biological Science and Biotechnology, Hannam University, Korea

본 연구를 통해서 우엉뭉뚝날개나방의 분류학적 재검토가 실시 되었다. 우엉뭉뚝날개나방은 뭉뚝날개나방과(Choreutidae)에 속하며, 유충은 우엉, 쑥갓 및 엉겅퀴 등의 엽육을 가해하는 해충이다. 현재 국내에서는 우엉뭉뚝날개나방의 정명을 *Tebenna issikii* (Matsumura, 1931)로 표기하고 있으나, 일본과 중국 등 해외에서는 *Tebenna micalis* (Mann, 1857)를 정명으로 인정하고 있다. 따라서, 국제동물명명규약에 의거하여 *Tebenna issikii* (Matsumura, 1931)를 *Tebenna micalis* (Mann, 1857)의 동종이명으로 학명 수정을 제안하고자 한다.

검색어: 우엉뭉뚝날개나방, 뭉뚝날개나방과, 학명, 정명

P30

Four species of the subfamily Acrocercopinae (Lepidoptera: Gracillariidae) from Korea

Da-Som Kim[1], Jae-In Oh[2], Ji-Young Lee[2], Dong-Myoung Kim[2], Jin-Sung Kweon[2], So-Yeon Kim[2], Soo-Jeong Park[2], Jun-Min Seo[2], Sang-Yoon Kim[2], June-Hyeok Jeong[2] and Bong-Kyu Byun[2]
[1]National Science Museum, Daejeon, Korea
[2]Department of Biological Science and Biotechnology, Hannam University, Korea

In this study, four species of the subfamily Acrocercopinae, *Borboryctis euryae* Kumata & Kuroko, 1988, *Deoptilia heptadeta* (Meyrick, 1936), *Gibbovalva magnoliae* Kumata & Kuroko, 1988, and *Psydrocercops wisteriae* (Kuroko, 1982) are reported for the first time from Korea. Also, four genera, *Borboryctis* Kumata & Kuroko, 1988, *Deoptilia* Kumata & Kuroko, 1988, *Gibbovalva* Kumata & Kuroko, 1988, *Psydrocercops* Kumata & Kuroko, 1988 are recorded as new to Korea. All available information, including check list, host plants and images of adults and genitalia for species is provided.

Key words: Gracillaridae, Acrocercopinae, new record, leaf-miners, Korea

P31

Korean species of the genus *Acrocercops* (Lepidoptera: Gracillariidae)

Da-Som Kim[1], Jae-In Oh[2] and Bong-Kyu Byun[2]
[1]National Science Museum, Daejeon, Korea
[2]Department of Biological Science and Biotechnology, Hannam University, Korea

This study was conducted to review of the genus *Acrocercops* Wallengren, 1881, belonging the subfamily Acrocercopinae of the family Gracillariidae, from Korea. The genus *Acrocercops* was established by Wallengren in 1881, including 324 described species worldwide. In this study, a total of 5 species are recognized from Korea. Among them, one species, *Acrocercops distylii* Kumata & Kuroko, 1988, is reported for the first time from Korea. All available information, including check list, host plants and images of adults and genitalia for species is provided.

Key words: Gracillaridae, *Acrocercops*, new record, leaf-miners, Korea

P32

Genus *Aristaea* (Lepidoptera: Gracillariidae) in Korea

Da-Som Kim[1], Jae-In Oh[2] and Bong-Kyu Byun[2]
[1]National Science Museum, Daejeon, Korea
[2]Department of Biological Science and Biotechnology, Hannam University, Korea

This study was conducted to review of the genus *Aristaea* Meyrick, 1907, belonging the subfamily Gracillariinae of the family Gracillariidae, from Korea. The genus *Aristaea* was established by Meyrick in 1907, including 12 described species worldwide. In this study, genus *Aristaea* Meyrick, 1907 with two unrecorded species are recognized from Korea. Among them, two species, *Aristaea bathracma* (Meyrick, 1912) and *A. pavoniella* (Zeller, 1847) are reported for the first time from Korea. All available information, including check list, host plants and images of adults and genitalia for species is provided.

Key words: Gracillaridae, Aristaea, new record, leaf-miners, Korea

P33

Taxonomic review of the genus *Eteoryctis* (Lepidoptera: Gracillariidae) from Korea

Da-Som Kim[1], Jae-In Oh[2] and Bong-Kyu Byun[2]
[1]National Science Museum, Daejeon, Korea
[2]Department of Biological Science and Biotechnology, Hannam University, Korea

This study was conducted to review of the genus *Eteoryctis* Kumata & Kuroko, 1988, belonging the subfamily Acrocercopinae of the family Gracillariidae, from Korea. The genus *Eteoryctis* was established by Kumata & Kuroko in 1988, including only 4 described species worldwide. In this study, a total of 3 species are recognized from Korea. In this study, one species, *Eteoryctis minimus* sp. nov., is described as new to science. Also, one species, *E. picrasmae* Kumata & Kuroko, 1988, is reported for the first time from Korea. All available information, including check list, host plants and images of adults and genitalia for species is provided.

Key words: Gracillaridae, *Eteoryctis*, new record, leaf-miners, Korea

P34

A new species of the genus *Futasujinus* Ishihara (Hemiptera: Auchenorrhyncha: Cicadellidae: Deltocephalinae) from Korea

Eunji Kim[1,2] and Sunghoon Jung[1,2]
[1]Laboratory of Systematic Entomology, Department of Applied Biology, Chungnam National University
[2]Department of Smart Agriculture Systems, Chungnam National University

The Old World leafhopper genus *Futasujinus* belonging to the tribe Paralimnini of the subfamily Deltocephalinae (Hemiptera: Auchenorrhyncha: Cicadellidae), it was established by Ishihara (1953) for a single species, *Deltocephalus candidus* Matsumura, 1914 from Japan. Up to date, a total of eight species have been described from China, Japan, Korea, Mongolia, and Russia. In this study, a new species of genus *Futasujinus* is described from Korea. Description, photographs of new species and a key to the *Futasujinus* species are presented

Key words: *Futasujinus*, Hemiptera, Korea, Leafhopper, new species

P35

First record of genus *Plutarchia* (Hymenoptera: Chalcidoidea: Eurytomidae) in Palearctic region, with two new species from Korea

Duk-Young Park[1] and Seunghwan Lee[1,2]
[1]Laboratory of Insect Biosystematics, Department of Agricultural Biotechnology, Seoul National University
[2]Research Institute of Agriculture and Life Sciences, Seoul National University

The genus *Plutarchia* Girault, 1925 is a comparatively small group with 13 valid species in the family Eurytomidae. Most species of this group are restrictively reported in the Oriental and one in the Afrotropical region. Their biology is not well known, but some species are recorded as parasitoids of Diptera and Lepidoptera.

Two new species of *Plutarchia* are described from Korea as the first record of the genus from the Palearctic region. The descriptions and photos of diagnostic characteristics of new species are provided.

Key words: new species, new record, parasitoid, taxonomy

P36

Checklist of island insects from Korea

Dong-June Lee[1], Seung-Jin Roh[1], Jae-Seok Lee[1], Yoon-Ho Kim[2], Sang-Woo Jeong[2], Dae-Hyun Lee[2], Jae-Ho Ko[2], Jae-Ha Lee[2] and Jong-Ok Lim[3]
[1]Division of Zoology, Honam National Institute of Biological Resources
[2]DASARI Research Institute of Bio Resources
[3]Department of Life and Environmental Sciences, Wonkwang University

섬은 면적 당 수많은 고유종이 서식하며 특수한 생태계를 유지하고 있는 지역이다. 국내에는 3,348개의 섬이 있으며, 이는 전세계에서 4번째로 많은 수이다(한국해양수산개발원). 곤충은 다양성이 매우 높은 분류군으로 한반도의 곤충은 19,809종(환경부, 2021)이 밝혀져 있으나, 섬 지역 종 현황은 정리되어 있지 않아 재정립이 필요하다. 따라서 본 연구를 통해 국내 섬 지역 내 분포하는 곤충종 현황을 파악하고 목록 구축을 하여 섬 생물 보전 및 활용 연구에 기준이 되는 기반 자료로 활용하고자 한다.

검색어: 섬, 곤충상, 유인도서, 무인도서, 특정도서

P37

A new record of the genus *Essigella* Del Guercio (Hemiptera: Aphididae: Lachninae) from Korea

Minho Lee[1,2], Mariusz Kanturski[3], and Seunghwan Lee[1,2*]

[1]Insect Biosystematics Laboratory, Department of Agricultural Biotechnology, Seoul National University, Seoul 08826, Korea

[2]Research Institute of Agriculture and Life Sciences, Seoul National University, Seoul 08826, Korea

[3]Zoology Research Team, Institute of Biology, Biotechnology and Environmental Protection, Faculty of Natural Sciences, University of Silesia in Katowice, Bankowa 9, 40–007 Katowice, Poland

The genus *Essigella* Del Guercio, 1909 (Aphididae: Lachninae: Eulachnini) is a Nearctic with about 17 species and feeds on leaves of *Pinus* spp. (Pinaceae). This genus is morphologically similar to *Eulachnus* Del Guercio, 1909, but the difference is that 5–segmented antennae. In this study, we report a new record of *Essigella* from Korea. Description, photgraphs of the species, host plant and mitochondrial *cytochrome c oxidase subunit I* (COI) data.

Key words: Aphids, new genus, DNA barcoding, Korean Peninsula

P38

A new species of the genus *Separatatus* Chen & Wu (Hymenoptera: Braconidae: Alysiinae) from South Korea

Ju-Hyoeng Sohn[1], Cornelis van Achterberg[2], Sangjin Kim[1], Jongok Lim[3] and Hyojoong Kim[1*]

[1]Animal Systematics Lab., Department of Biological Science, Kunsan National University, Gunsan, 54150, Republic of Korea

[2]State Key Laboratory of Rice Biology and Ministry of Agriculture / Key Lab of Agricultural Entomology, Institute of Insect Science, Zhejiang University, Hangzhou, 310058, China

[3]Department of Life and Environmental Sciences, Wonkwang University, Iksan, JB 54538, Korea

The genus *Separatatus* Chen & Wu, 1994 (Braconidae: Alysiinae) is recognized for the first time from South Korea, as recording of its new species. In this study, we describe a species, *Separatatus megagnathus* sp. nov., as new to science. The genus and species were described and illustrated herein. An identification key to the Korean species is provided. In addition, mitochondrial *cytochrome c oxidase subunit I* (*COI*) has been analyzed for corroborating identification of this new species.

Key words: *COI* barcode, cyclostome, natural enemy, koinobiont, parasitoid wasp, systematics, taxonomy

P39

First record of *Aleiodes thirakupti* (Hymenoptera: Braconidae) from South Korea

Gyeonghyeon Lee, Ju-Hyeong Sohn, Sangjin Kim and Hyojoong Kim*
Animal Systematics Lab. Department of Biological Science, Kunsan National University, Gunsan 54150

Most parasitoid insects are known as hymenopterans and use strategy in which one or more wasp larvae develop on a single host and are killed before reproduction. The subfamily Rogadinae is one of the species-rich braconid group, of which endoparasitoids mostly attack larvae in many sort of lepidopteran families and are characterized by pupating within the mummified host larval skin. The species of *Aleiodes* in Rogadinae are all koinobiont endoparsitoids of larva, thus the host larva is not permanently paralyzed but can continue growing and molting for a period of time although it is parasitized. It is considered that *Aleiodes* are beneficial because they act as biological control agents to naturally suppress forest pests. In this study, *Aleiodes thirakupti* is reported for the first time from South Korea, and this species will explain through provision of diagnosis, distribution, and illustration.

Key words: Taxonomy, Rogadini, Cyclostome, Mummification, Natural enemy

P40

Taxonomic review of the family Issidae Spinola (Hemiptera: Auchenorrhyncha: Fulgoroidea) from Korea

Jaekook Park[1,2] and Sunghoon Jung[1,2*]
[1]Laboratory of Systematic Entomology, Department of Applied Biology, Chungnam National University, Korea
[2]Department of Smart Agriculture Systems, Chungnam National University, Korea

We taxonomically reviewed the planthopper family Issidae (Hemiptera: Auchenorrhyncha: Fulgoroidea) from Korea, and a total of five species are recognized. Diagnoses of the species are presented with photographs of habitus and genitalia based on male specimens. We also added new host plant records for some species, and a key to the Korean Issidae is provided.

Key words: Fulgoroidea, Issidae, Korea, pest, taxonomic review

P41

New morphological type records of *Vollenhovia nipponica* (Hymenoptera: Formicidae) in Korea

Jinsoo Kim[1], Seongwon Yun[2], Jiwon Sohn[3], Jonghyun Park[4] and Seunggwan Shin[1]
[1]School of Biological Sciences, Seoul National University
[2]Department of Forest Landscape Architecture, Sangji University
[3]Department of Life Science, Chung-Ang University
[4]Division of Life Sciences, Korea University

Vollenhovia nipponica is known as the only social parasitic ant species live within the congeneric host species, *Vollenhovia emeryi*. In our recent investigation, we found a group of *Vollenhovia* species which was a social parasite of *V. emeryi,* but differ in the body coloration and on the petiolar structure comparing with *V. nipponica*. Because of these distinct morphological characters, that group could potentially be different species from *V. nipponica* based on a current taxonomic concept. In order to identify this group, we conducted two experiments: (1) Studying their morphological characters to clarify if they had an intermediate form or not. (2) DNA barcoding analysis using cytochrome c oxidase I (COI) to determine the genetic species concept of *Vollenhovia* genus. The result confirmed that the new morphological type samples were distinctly distinguished from the other *V. nipponica* without an intermediate phenotype. However, the molecular identification result could not come to a consensus with morphological study. The genetic distance was too close to determine the new morphological type as a different species comparing with *V. nipponica*. Thus, we concluded that they were a new morphological type of *V. nipponica* due to their genetic distance below the interspecies level, even if they had discontinuous morphological variations. Finally, we suggest new morphological type of *V. nipponica* inhabit in Korea, with describing their morphological characters in this study.

Key words: *Vollenhovia nipponica*, DNA Barcoding, COI, Genetic Distance, Morphological Variation

P42

First record of a parasitoid wasp, *Apanteles merope* (Braconidae: Microgastrinae) from South Korea

YeongHyeok Yu and Hyojoong Kim
Animal Systematics Lab., Department of Biological Science, Kunsan National University, Gunsan, 54150, Republic

The genus *Apanteles* Foerster, 1863 belonging to the family braconidae is known to include 1,300 species worldwide. This genus is a perparasitic wasp on Lepidoptera. Therefore, it is widely used as a biological control. In this study, *Apanteles merope* Nixon,1965 is recognized for the first time in South Korea, of which specimens were firstly collected from Gunsan, South Korea. This finding is important because this species is known to be phylogenetically complex. It was known that *A. merope* mainly parasitizes in the larvae or eggs in Erebidae. Descriptions, diagnosis, distribution and illustration are provided.

Key words: koinobiont, identification, natural enemy, taxonomy, phylogeny

P43

Taxonomic note of the little known parasitoid wasp, *Phaedrotoma vermiculifera* (Braconidae: Opiinae) in South Korea

Yunjong Han and Hyojoong Kim*

Animal Syst. Lab., Department of Biological Science, Kunsan National University, Gunsan 54510, Republic of Korea

The genus *Phaedrotoma* Foerster, 1862 (Hymenoptera: Braconidae: Opiinae) parasitizes in larvae of fruit fly (Diptera: Tephritidae), mining fly (Diptera: Agromyzidae), Ephydridae, Scathophagidae and Drosophilidae, of which 13 species are recorded in South Korea. In this study, description and diagonostic illustration of *Phaedrotoma vermiculifera* Li & van Achterberg, 2013 are provided.

Key words: Ichneumonoidea, morphological identification, koinobiont, natural enemy, parasitoid

P44

A new species of the genus *Toxares* (Hymenoptera: Braconidae: Aphidiinae) from South Korea

Sangjin Kim[1], Željko Tomanović[2,3], Andjeljko Petrović[2], Jelisaveta Čkrkić[2], Gyeonghyoen Lee[1] and Hyojoong Kim[1]

[1]Animal Systematics Lab., Department of Biological Science, Kunsan National University, Gunsan 54150, Republic of Korea

[2]University of Belgrade, Faculty of Biology, Institute of Zoology, Studentski trg 16, 11000 Belgrade, Serbia

[3]Serbian Academy of Sciences and Arts, Knez Mihailova 35, 11000, Belgrade, Serbia

The genus *Toxares* Haliday, 1833. is a small taxon of Aphidiinae (Hymenoptera: Braconidae), consisting of 4 species in the world. In this study, one *Toxares* species is recorded as new to science from South Korea. Descriptions and illustrations of the new specis, *T. koreanus* sp. n., are provided. Phylogenetic tree reconstructed using combination of the mitochondrial *cytochrome c oxidase subunit I* and the nuclear gene for D2 region of *28S rRNA* revealed the phylogenetic position of the genus *Toxares* within Aphidiinae.

Key words: DNA barcoding, parasitoid wasps, phylogenetics, systematics, taxonomy

P45

First record of the scathophagid fly species *Cordilura shatalkini* Ozerov, 1997 (Diptera: Scathophagidae) from Korea with the first female description

Sangjin Han, Jonghwan Choi and Seunggwan Shin
School of Biological Sciences, Seoul National University

The family Scathophagidae known as dung flies, consisting of two subfamilies, is abundant and ubiquitous throughout the world. To date, only three species of this family have been recorded from the Korean fauna. In this study, the scathophagid fly species *Cordilura shatalkini* Ozerov, 1997 is recorded for the first time in Korea. Six specimens including 1 male and 5 females have been collected by Malaise traps. Due to no record of morphological description of female specimen yet, further DNA barcoding using the mitochondrial cytochrome c oxidase I gene (COI) for molecular identification of female specimens was conducted. As a result of COI-based DNA barcoding, this study provides the first female description.

Key words: *Cordilura shatalkini*, Diptera, Korea, newly recorded, Scathophagidae, Scathophaginae, taxonomy

P46

Confirmation on the presence of *Melolontha frater* Arrow (Scarabaeidae: Melolonthinae: Melolonthini) in the Korean Peninsula

Jihoon Kim and Seunggwan Shin
School of Biological Sciences, Seoul National University, Seoul, 08826, South Korea

Genus *Melolontha* Fabricius comprises seventeen species in the Palaearctic and Oriental regions. In the Korean Peninsula, four species had been recorded, but two species were regarded as misidentification and thus removed from the Korean species list. Therefore, previous studies considered that only two species of *Melolontha* inhabit the Korean Peninsula. However, during recent investigations, one of the removed species, *M. frater* Arrow, was re-confirmed and identified as a nominal subspecies. In this study, we re-record this species on the Korean Peninsula with female specimens, and provide a diagnosis with photographs. We also discuss about research history of *Melolontha* species in Korea.

Key words: *Melolontha frater*, Scarabaeidae, Melolonthinae, taxonomic review, Korean Peninsula

P47

Acrobasis encaustella Ragonot, 1893 (Lepidoptera, Pyralidae, Phycitinae) new to Korea

Tae-uk Yu[1], Un-hong Heo[2], Soowon Cho[1]
[1]Insect Systematic Bioinformatics Lab., Chungbuk National University,
[2]Research Institute for East Asian Environment and Biology

The genus *Acrobasis* Zeller (1839) is the largest genus in the subfamily Phycitinae, distributed throughout the world. About 80 species have been reported worldwide, and 13 species are currently known in Korea. We recently observed *Acrobasis encaustella* Ragonot, 1893, and were able to identify the species based on the morphological characteristics of the adult specimens and their genitalia. This species is similar to *A. fuscatella* Yamanaka, 2004, *A. sasakii* Yamanaka, 2003 and *A. subceltifoliella* Yamanaka, 2006, but can be easily distinguished based on male genital characteristics, especially gnathos. Also, the genitalia are very similar to those of *A. rufilimbalis* (Wileman, 1911) but can be distinguished based on the different wing patterns. Here we provide a diagnosis and brief description, along with images of adult male and its genitalia.

Key words: *Acrobasis encaustella,* Korean fauna, new record

P48

Holcocera sakura Ohshima, 2003 (Lepidoptera: Blastobasidae: Holcocerinae) new to Korea

Jinho Na, Junmo Koo and Soowon Cho
Department of Plant Medicine, Chungbuk National University, Cheongju, Korea

In the family Blastobasidae (Lepidoptera: Gelechioidea), 23 genera and more than 500 species are described worldwide, and 11 species are known in Korea. Among them, *Hypatopa silvestrella* Kuznetzov, 1984, *H. tianshanica* Sinev, 1993, and *Tecmerium scythrella* (Sinev, 1986), of the subfamily Holcocerinae, have been recorded in Korea. Here we present *Holcocera sakura* Ohshima, 2003 as an unrecorded genus and species in Korea. We provide pictures of adults and their genitalia with a diagnosis and brief description.

Key words: microlepidoptera, new record, Korean fauna

P49

First record of the genus *Appolonius* (Heteroptera: Lygaeoidea: Rhyparochromidae) from Korea

Geunho Jang[1,2] and Sunghoon Jung[1,2]
[1]Department of Smart Agriculture Systems, Chungnam National University
[2]Department of Applied Biology, Chungnam National University

The genus *Appolonius* belongs to the tribe Drymini of the family Rhyparochromidae. *Appolonius* comprises 12 species worldwide, whereas only two species have been reported from the Palearctic region. In this study, we report the genus *Appolonius* for the first time from Korea with *A.oblongus*. We also present diagnosis, figures, genitalia for the genus and species.

Key words: Lygaeoidea, Rhyparochromidae, *Appolonius*, Korea

P50

A new record of a fungivorous beetle, *Ditrichocis bifasciatus* (Reitter, 1887) (Coleoptera: Ciidae), from South Korea

Gyu Young Han, Young-Min Shin, Ah-Young Kim and Il-Kwon Kim
Division of Forest Biodiversity, Korea National Arboretum, Pocheon, Republic of Korea

Ciidae is a cosmopolitan group of fungivorus beetles, containing about 700 described species in 51 genera worldwide. *Ditrichocis* Lawrence, 2016 in Ciinae is newly recognized from South Korea, based on *Ditrichocis bifasciatus* Reitter (1887), in the present study. The species was collected from fungal hosts, namely *Cerrena unicolor* (Bull.) Murrill and *Pleurotus cornucopiae* (Paulet) Rolland, from islands located in Sinan-gun, Jeollanam-do. In the present study, description and images of adults, distribution, information of host fungi are provided. Also a key to Korean genus of the subfamily Ciinae is presented.

Key words: *Ditrichocis bifasciatus*, new record, Ciidae, fungivorous, host fungi

P51

Taxonomic review of the genus *Scarites* (Coleoptera: Carabidae) from Korea

Myeong Cheol Kim, Taeyeong Kwon, Hee Soo Lee, Jong Bong Choi, Eun Yeong Choi and Jong Kyun Park
College of Ecology and Environmental Science, Kyungpook National University, Sangju, Korea

In Korea, a total of 3 species belonging to genus *Scarites* were recorded. This taxon inhabits the ecotone where borders with water and land. Also they are predators and scavengers in the ecosystem. However, they are morphologically similar that is difficult to identify between interspecies and taxonomic studies of tribe-level are lacking. In this study, photograph of habitus and male genitalia, taxonomic pictorial key, and diagnostic characteristics of each species are provided.

Key words: *Scarites*, Carabidae, pictorial key, taxonomy, Korea

P52

First record of *Aphis solanella* (Hemiptera: Aphididae) in South Korea

Hyeban Namgung and Hyojoong Kim
Animal Systematics Lab., Department of Biological Science, Kunsan National University, Gunsan, 54150, Republic of Korea

Aphis solanella had been classified as a subspecies of *Aphis fabae* and then was recognized as a species. When *Aphis fabae* was recorded in South Korea in 2006, most of specimens were morphologically identical to *Aphis fabae solanella*, but were reported as *Aphis fabae* without subspeice division. Since *Aphis fabae* and *Aphis solanella* are currently recognized as different species, we report *Aphis solanella* as unrecorded species with redescription and illustrations.

Key words: aphids, taxonomy, *Aphis fabae* group, pest

P53

The first record of *Periphyllus diacerivorus* Zhang, 1982 (Hemiptera: Aphididae: Chaitophorinae) from Korea with description of the unknown morph

Jun Hyeok Ko[1], Wonhoon Lee[1,2]
[1]Department of Plant Medicine, Gyeongsang National University
[2]Institute of Agriculture&Life Science, Gyeongsang National University, Jinju 52828, Repubilc of Korea

The genus *Periphyllus* van der hoeven, 1863 (Aphididae: Chaitophoriane) consist of 50 monoecious and holocylic species. *Periphyllus diacerivorus* Zhang, 1982 has been recorded China and associated with *Acer mono*. But *P. diacerivorus* seems to be a synonym by *Periphyllus kuwanaii,* cause the two species are similar in apterous female form. To date, the taxonomy of this species in the genus *Periphyllus* is still confused. In 2021, *P. diacerivorus* is recognized for the first time in South Korea, of which specimens were firstly collected from Suncheon, South Korea. Therefore, we reported unknown morph description and alive picture, measurement, host plant, distribution.

Key words: *Acer mono*, *Periphyllus*, unknown morph, Korea

P54

Survey for pests on a small-cultivated crop, strawberry (*Fragaria x ananassa*)

Juhwan Ahn[1,2] and Sora Kim[1]
[1]Department of Plant Protection & Quarantine, Graduate School of Plant Protection & Quarantine, Jeonbuk National University
[2]DAEYU Co. Ltd.

딸기는 익산의 금마면, 낭산면과 왕궁면에서 소면적으로 재배되는 주요 작물로, 본 연구는 익산 딸기재배농가 20곳을 대상으로 발생하는 주요 해충과 그 피해증상에 대한 연구이다. 조사 결과, 총 7목에 속하는 10종의 해충이 발생하는 것으로 확인되었다. 그 중, 가장 발생 피해가 큰 해충은 점박이응애(*Tetranychus urticae*), 애못털진딧물(*Chaetosiphon minus*)과 작은뿌리파리(*Bradysia agrestis*) 순으로 조사되었다. 점박이응애와 애못털진딧물은 식물의 잎과 과실부위를 흡즙을 하여 생육을 지연시키는 피해가 관찰되었고, 작은뿌리파리는 지제부를 직접 가해하여 양분의 이동을 저해시켜 작물의 생장을 지연시킬 뿐 아니라, 시들음 증상을 추가로 일으키는 것으로 관찰되었다. 그 외, 딸기잎선충(*Aphelenchoides fragariae*), 꽃노랑총채벌레(*Frankliniella occidentalis*)와 애지렁이(Criconematidae sp.)도 일부 농가에 피해를 주는 것으로 확인되었다.

검색어: 딸기, 해충조사, 조사목록, 분류

P55

A list of insect pests on sweet potato crops grown in large-area units in Jinan

Soon Hong Yim[1,2] and Sora Kim[1]

[1]Department of Plant Protection & Quarantine, Graduate School of Plant Protection & Quarantine, Jeonbuk National University

[2]Jinan Agirculture Technology Center

2015년도부터 진안군에서 고구마(*Ipomoea batatas* L. Lam)는 대면적 단위(90ha이상) 작물로 재배되고 있다. 본 연구는 고구마에서 발생하는 해충의 친환경관리를 위한 기초 자료 구축을 목적으로 수행되었다. 그 결과, 2002~2007년까지의 문헌 자료 조사를 통해, 고구마를 가해하는 해충은 총 43종으로 정리되었다. 이 중, 뒷날개흰밤나방,(*Aedia leucomelas*), 담배거세미나방(*Spodoptera litura*), 큰검정풍뎅이(*Holotrichia parallela*) 및 꽈리허리노린재(*Acanthocoris sordidus*) 4종은 앞으로 대발생이 우려되는 종으로 조사되었다. 본 연구결과를 기반으로, 앞으로 고구마 해충에 대한 현장 조사를 통해, 적합한 방제 전략 대책을 세우고자 한다.

검색어: 해충, 고구마, 분류, 진안

P56

The first report of the family Hybotidae (Diptera: Empidoidea) in South Korea, with the description of three new species

Seunghun Jung[1], Sangil Kim[1,2] and Seunggwan Shin[1]

[1]School of Biological Sciences, Seoul National University, Seoul, 08826, Republic of Korea

[2]Museum of Comparative Zoology and Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA 02138, USA

The well-defined monophyletic family Hybotidae includes ~3000 described species in 64 genera worldwide. The species diversity in this group parallels its morphological and behavior diversity, drawing attention from biologists. Yet our current taxonomic knowledge of Hybotidae from the Eastern Palearctic region outside of China remains poorly known. Herein, we report the family Hybotidae from South Korea for the first time, and describe three new species of the genus *Hybos*. We provide description with illustrations of diagnostic characters. In addition, we present phylogenetic analysis results based on the mitochondrial cytochrome oxidase *c* subunit I (COI) gene sequence data, which lend support to our proposed taxonomic treatment.

Key words: *COI* barcode, *Hybos*, Hybotidae, South Korea, New records

P57

First record of the genus *Setoptus* (Acari: Phytoptidae) on five-needle pine from Korea

Woong Ki[1], Jong-Ho Lee[2] and Ki-Jeong Hong[1*]
[1]Dept. of Plant Medicine, Sunchon National University, Suncheon 57922, Korea
[2]Dept. of Plant Quarantine, Animal and Plant Quarantine Agency, Gimcheon 39660, Korea

The family Phytotidae includes 164 species and 20 genera (Zhang *et al*., 2011). Among them, the members of genus *Setoptus* are described 20 species worldwide (Amrine *et al*., 2003) and produce the needle sheath stunting symptom of *Pinus* (Boczek and Shevchenko, 1996). In this study, the genus *Setoptus* is first reported from Korea collected on five-needle pine (*Pinus parviflora* Siebold & Zucc.). It is identified as *Setoptus koraiensis* Kuang & Hong, 1995 recorded from Northeast China on *Pinus koraiensis* Siebold & Zucc. The characteristics of this species and genus are three setae (a internal vertical seta (*vi*) and two scapular setae (*sc*)) and spreading granules on prodorsal shield.

Key words: *Setoptus*, Eriophyid mite, *Pinus parviflora*, New record, Korea

P58

Four major insects on imported cut flowers in Korea during 2016-2020

Hyemi Park and Youngjin Park
Plant Quarantine Technology Center, Animal and Plant Quarantine Agency

본 연구는 병해충정보시스템(PIS)을 이용하여 최근 5년간(2016년- 2000년) 수입된 절화류에서 검출된 주요 4대 해충의 동향을 분석하였다. 2016년 1,798건의 해충이 검출되었으며, 2020년에는 3,185건으로 2배 가까이 증가하였다. 총 403종 12,320건의 해충이 발견되었으며, 가장 많이 검출된 주요 4대 해충은 *Frankliniella occidentalis*(2,100건), *Thrips tabaci*(1,253건), *Bemisia tabaci*(775건), *F. intonsa*(597건)이며 연도 별로 일부 해충의 검출건수가 꾸준히 증가했다. *F. occidentalis*은 네덜란드(1,142건), 중국(290건)산 절화류에서 가장 많이 발생했으며 장미와 국화절화에서 주로 검출됐다. *T. tabaci*는 73%인 911건이 네덜란드산이었으며 베로니카, 카네이션, 아스틸베젤화 등 다양한 품목에서 발견했다. *B. tabaci*는 96%인 743건이 국화절화에서 발견되었으며 그 중 717건은 중국에서 들어왔다. *F. intonsa*는 주로 중국(352건), 네덜란드(119건)에서 들어왔으며 52.8%(315건)가 국화에서 검출됐다. 본 자료는 앞으로 유입 가능한 해충을 선제적으로 파악하여 차후 수입 절화류에서 발생하는 해충의 검역에 효율적으로 쓰이길 기대한다.

검색어: 식물검역, 수입 절화, *Frankliniella occidentalis*, *Thrips tabaci*, *Bemisia tabaci*, *F. intonsa*

P59

Complete mitochondrial genome of *Ceriagrion nipponicum* (Odonata: Coenagrionidae)

Jee-Young Pyo[1], Jeong Sun Park[1], Sung Soo Kim[2] and Iksoo Kim[1]
[1]College of Agriculture & Life Science, Chonnam National University
[2]Institute for East Asian Environment and Biology, Republic of Korea

Ceriagrion nipponicum Asahina, 1967 (Odonata: Coenagrionidae) is listed as a climate-sensitive biological indicator species in Korea, which is expanding to northward. We sequenced the complete mitochondrial genome (mitogenome; 16,874 bp) of *C. nipponicum* collected in South Korea. The A+T-rich region was the longest in sequenced Zygoptera at 2,125 bp. The gene arrangement of the species was identical to that of commonly found in the majority of the insects. Phylogenetic analyses using the concatenated sequences of 13 PCGs and two rRNA genes of the representative Zygopteran mitogenomes by Bayesian inference method and Maximum-likelihood methods revealed the sister relationship between *C. nipponicum* and congeneric species *C. fallax* with the highest nodal supports in both analyses.

Key words: Mitochondrial genome, *Ceriagrion nipponicum*, Climate-sensitive species

P60

Complete mitochondrial genomes of ten Korean domesticated silkworm strains (*Bombyx mori*: Lepidoptera: Bombycidae)

Jong Woo Park[1], Jeong Sun Park[2], Su Min Park[2], Seong-Wan Kim[1], Kee-Young Kim[1] and Iksoo Kim[2*]
[1]Department of Agricultural Biology, Rural Development Administration
[2]Department of Applied Biology, Chonnam National University

In this study, for subsequent diagnostic marker development, we sequenced the complete mitochondrial genomes (mitogenome) of ten domesticated silkworm strains recommended for powder-type commercial products by the Korean government. The complete mitogenome of the ten strains contained the gene sets, gene arrangement, and nucleotide compositions typical in Lepidoptera. Phylogenetic analyses, along with 35 available mitogenome sequences of the *B. mori* strains originating from several countries, including Korea, showed only one distinct, independent group, composed of a few strains of Chinese origin. This result suggests that silkworm strains preserved in each country are mostly similar, even after substantial time has lapsed after domestication from the progenitor species, *B. mandarina.*

Key words: Mitochondrial genome, *Bombyx mori*, Domesticated silkworm, Phylogeny

P61

Addition of 20 new complete mitochondrial genome sequences for population genetic analyses of the wild silkmoth, *Bombyx mandarina* (Lepidoptera: Bombycidae)

Jeong Sun Park[1†], Jee-Young Pyo[1†], Min Jee Kim[2], Heon Cheon Jeong[3], Sung-Soo Kim[4] and Iksoo Kim[1*]
[1]Department of Applied Biology, Chonnam National University
[2]Honam Regional Office, Animal and Plant Quarantine Agency
[3]Korea Native Animal Resources Utilization Convergence Research Institute, Soonchunhyang University
[4]Research Institute for East Asian Environment and Biology, Republic of Korea

Bombyx mandarina (Lepidoptera: Bombycidae), the presumed ancestor of *B. mori*, has long been a subject of study to illustrate the geographic variation in relationship to origin of *B. mori*. We report 20 mitochondrial genome sequences of *B. mandarina* collected from two Korean localities. Phylogenetic analysis using Baysian inference and Maximum-likelihood methods suggest that the 24 individuals of *B. mandarina* collected in six Korean localities formed a strong group with the higher nodal supports together with those originated from northern China. This result suggests that gene flow between the two regions was substantial enough to prevent genetic isolation, even though the two regions are currently separated by the Yellow Sea.

Key words: Mitochondrial genome, *Bombyx mandarina*, Wild silkworm, Phylogeny

P62

A preliminary analysis for superfamilial and familial relationships of lepidopteran Gelechioidea within Ditrysia inferred from mitochondrial genome sequences

Jeong Sun Park[1], Jun Seong Jeong[1], Su Yeon Jeong[1], Min Jee Kim[1,2], Jong Seok Kim[1], Sung Soo Kim[3] and Iksoo Kim[1,*]
[1]Department of Applied Biology, Chonnam National University
[2]Honam Regional Office, Animal and Plant Quarantine Agency
[3]Research Institute for East Asian Environment and Biology, Republic of Korea

The complete mitochondrial genomes (mitogenomes) of ten species in Gelechioidea, along with a total of nine in Zygaenoidea, Cossoidea, and Sesioidea were sequenced and compared to those of other ditrysian superfamiles in genomic characteristics. Furthermore, these 19 mitogenome sequences were combined with 148 public data belonging to ditrysian superfamilies (excluding Macroheterocera) to reconstruct phylogenetic relationships among ditrysian superfamilies, particularly the position of Gelechioidea in the lepidopteran trees and among gelechioid families. As a preliminary result, Gelechioidea was placed well within the Obtectomera sensu lato, but, Papilionoidea was unconventionally placed as an earlier derived superfamily than Gelechioidea. Within Gelechioidea a few previously recognized clades were well supported, but others were not. Current analysis lacks for macroheterceran superfamilies. Thus, further scrutinized analysis with more available taxa is undergoing.

Key words: Ditrysia, Mitochondrial genome, Zygaenoidea, Cossoidea, Sesioidea, Gelechioidea, Phylogeny

P63

Classification and characterization of the immune hemocyte in the last larva of *Argyreus hyperbius* (Linnaeus)

Youngwoo Cho[1], Min-Soo Go[2], Jun Ho Lee[1], Hyun Kyung Yun[1], Ki-byung Park[3], Jangwoo Park[4] and Saeyoull Cho[1]

[1]Department of Interdisciplinary Program in Smart Agriculture, Kangwon National University, [2]Changnyeong Agricultural Technology Center, [3]JungBubiotech Co., Ltd., [4]Osang Kinsect Co.

In this study, we used light and electron microscopic analysis to characterize the hemocytes in the last larva of *Argyreus hyperbius (Linnaeus)*. Granulocytes (GR), plasmatocytes (PL), oenocytoids (OE), spherulocytes (SP), prohemocytes (PR) and adipohemocytes (AD) were classified based on their size and ultrastructural differences in the circulating hemocytes. Many dark granules in the GR's cytoplasm were observed and well-developed mitochondria, endoplasmic reticulum (ER), nucleus, and Golgi complex were also seen. To identify the predominant immune hemocytes, we injected carboxylate-modified polystyrene latex beads and *E. coli* particles into the hemocoel of the larvae. In response to the pathogens, only granulocytes underwent morphological changes, including the extension of fan (or amoeba)-like structures from their membrane, and had bacterial particles in their cytoplasm. Lysosomes in the cytoplasm of the granulocytes were activated to remove the pathogens.

Key words: *Argyreus hyperbius*, hemocytes, granulocytes, cell immune, lysosome

P64

Phagocytosis iummune priming associated with granulocytes in the cricket, *Gryllus bimaculatus*

Youngwoo Cho[1], Min-Soo Go[2], Jun Ho Lee[1], Hyun Kyung Yun[1], Ki-byung Park[3], Jangwoo Park[4] and Saeyoull Cho[1]

[1]Department of Interdisciplinary Program in Smart Agriculture, Kangwon National University, [2]Changnyeong Agricultural Technology Center, [3]JungBubiotech Co., Ltd., [4]Osang Kinsect Co.

Immune priming is immune memory-like process described in invertebrate such as insects, spider, and crab. We characterized the immune priming effects from *Gryllus bimaculatus*. We reported that granulocytes were identified as the professional immune cell that mediates nodulation, encapsulation, and phagocytosis of pathogens in this insect. After we pre-injected *E. coli* or *Bacillus thuringiensis* particles into the hemocoel of the larvae, granulocytes faster, sharper, and more rapid underwent their morphological changes to the second trial pathogens. To confirm these results, we performed flow cytometry analysis. Consistent with our microscope observations, the granulocytes were activated only after 1 h post-infection, and lysosomes were mostly activated at 2 h. These results suggest that pathogens are actively engulfed between 1 and 2 h post-infection by granulocytes.

Key words: *Gryllus bimaculatus*, hemocytes, granulocytes, immune priming, lysosome

P65

Effects of propolis on longevity and ethanol tolerance in *Drosophila melanogaster*

Joo Heon Cha and Young Ho Kim
Department of Applied Biology, Kyungpook National University

Propolis is one of the major products in apiculture industry and has been widely used as a health supplement because of its biological activity such as hepatoprotective, antioxidant, antibacterial, and anti-properties. In order to investigate the physiological effects of propolis, in this study, *Drosophila melanogaste* was reared in the artificial diet containing different concentration of propolis (0g, 1g and 5g of propolis per 100ml of artificial diet), then adult longevity and ethanol tolerance were compared. Extended adult longevity and higher ethanol tolerance were observed when fly was reared in the diet containing propolis, suggesting that propolis affects physiological response of *D. melanogaster*.

Key words: propolis, longevity, ethanol toleracne, *Drosophila melanogaster*

P66

Evaluation of stable reference genes for qRT-PCR analysis and transcription pattern of *AChE1* in five tissues of *Apis mellifera* treated with seven pesticides

YeongHo Kim[1], Hyemin Kim[2] and Young Ho Kim[1,2]
[1]Department of Ecological Science, Kyungpook National University
[2]Department of Applied Biology, Kyungpook National University

The honeybee, *Apis mellifera*, is one of the most economically important insects, but collapse of honeybee colony has been recently reported to be related with exposure to various pesticides. To determine the expression levels of genes putatively involved in metabolic pathway of pesticide in honeybee, selection of suitable reference genes is essential for conducting quantitative real-time PCR (qRT-PCR). Therefore, in this study, we analyzed amplification efficiencies of five candidate reference genes (*RPS5*, *RPS18*, *GAPDH*, *ARF1*, and *RAD1a*) and their expression stability values with four programs (geNorm, NormFinder, BestKeeper, and RefFinder) across the samples of five tissues (head, thorax, gut, fat body, and carcass) of honeybee exposed to seven pesticides (acetamiprid, imidacloprid, flupyradifurone, fenitrothion, carbaryl, amitraz, and bifenthrin). *RPS5* generally was identified to be the optimal reference gene. Furthermore, the expression level of *AChE1* was normalized with the selected reference gene.

Key words: Honeybee, pesticide, qRT-PCR, reference gene

P67

Behavioural and physiological regulation of protein and carbohydrates in mealworm larvae: A geometric analysis

Myung Suk Rho and Kwang Pum Lee
School of Agricultural Biotechnology, Seoul National University

Protein-carbohydrate regulation in the larvae of the mealworm beetle (*Tenebrio molitor* L.) was analyzed using the Geometric Framework for nutrition. In this study, the ingestive and post-ingestive responses were measured from *T. molitor* larvae that were subjected to choice and no-choice experiments. In the choice experiment, *T. moitor* larvae were simultaneously presented with one of two protein-biased foods (p35:c7 or p28:c5.6) and one of two carbohydrate-biased foods (p7:c35 or p5.6:c28). *T. molitor* larvae selected protein and carbohydrate in a ratio close to 1:1 over the first 15 days since the start of the experiment (days 0–15), but exhibited preference for carbohydrate-biased food over the next 15 days. The average protein:carbohydrate ratio selected over days 0–30 was 1:1.24. In the no-choice experiment, *T. molitor* larvae were restricted to one of seven foods with different protein and carbohydrate content (p0:c42, p7:c35, p14:c28, p21:c21, p28:c14, p35:c7, or p42:c0). On the p0:c42 food, consumption was greatly suppressed and no larvae completed their development. Across a range of these foods except p0:c42, *T. molitor* larvae consistently over-ate the surplus nutrient in the foods and showed a pattern of nutrient balancing similar to that previously described for other nutritional generalists. Despite having consumed substantially different amounts and ratios of macronutrients as larvae, *T. molitor* pupae in the no-choice food treatments had similar body nutrient composition, suggesting the presence of strong homeostatic regulation for body nutrient growth. Larval survivorship was significantly lower on two extremely imbalanced foods (p7:c35 and p42:0) than on more balanced foods. *T. molitor* larvae reared on p7:c35 suffered reduced biomass growth and delayed development compared with those on foods with higher protein content.

Key words: Protein, Carbohydrate, Feeding behaviour, Nutrient balancing, Geometric Framework, *Tenebrio molitor*

P68

Inducible expression of several *Drosophila melanogaster* genes encoding Juvenile Hormone Biding proteins by a plant diter-pene secondary metabolites, methyl lucidone

Sang Woon Shin[1], Jun Hyoung Jeon[2], Ji-Ae Kim[1], Doo-Sang Park[2], Young-Joo Shin[3] and Hyun-Woo Oh[1]
[1]Core Facility Management Center, Korea Research Institute of Bioscience and Biotechnology
[2]Biological Resource Center, Korea Research Institute of Bioscience and Biotechnology
[3]Department of Radiation Oncology, Sanggye Paik Hospital, Inje University

The multiple genes encoding Juvenile Hormone Binding Protein are present in all insect species. On the other hand, variety of Juvenile Hormone is limited in insects. This suggests the other roles of Juvenile Hormone Binding proteins in addition to its revealed role as Juvenile Hormone transporter. Here, we show that seven *D. melanogaster* Juvenile Hormone Binding Protein genes are inducible by methyl lucidone, a plant diterpene secondary metabolite, which functions as a Juvenile Hormone Disruptor both in vitro and in vivo. This proposes that the diversity of Ju-venile Hormone Binding Protein genes may be related to the presence of the diverse plant diterpene secondary metabolite molecules

Key words: Juvenile hormone, Juvenile Hormone Binding protein, Juvenile Hormone Disruptor, methyl lucidone

P69

AA15 lytic polysaccharide monooxygenase is required for chitinous cuticle turnover during insect molting

Myeongjin Kim[1], Seulgi Mun[1], Mi Young Noh[2], Karl J. Kramer[3], Subbaratnam Muthukrishnan[3] and Yasuyuki Arakane[1]
[1]Department of Applied Biology, Chonnam National University
[2]Department of Forest Resources, Chonnam National University
[3]Department of Biochemistry and Molecular Biophysics, Kansas State University

Lytic polysaccharide monooxygenases (LPMOs) catalyze the oxidative cleavage of glycosidic bonds in crystalline polysaccharides including chitin and cellulose. The recent discovery of a large assortment of LPMO-like proteins widely distributed in insect genomes suggests that they could be involved in chitin degradation in the cuticle, tracheae and peritrophic matrix during development. However, the physiological functions of insect LPMO15s are still undetermined. A phylogenetic analysis indicates that insect LPMO15s could be divided into at least four subgroups. In this study, we investigate the function of subgroup I LPMO15 (TcLPMO15-1) in the red flour beetle, *Tribolium castaneum*. RNAi studies show that TcLPMO15-1 is required for molting at all developmental stages. TEM analyses reveal failure of turnover of chitinous cuticle. These results indicate that TcLPMO15-1 plays an important role in cuticular chitin degradation, which is critical for completion of insect molting.

P70

Functional genomics of *MaTH* and *MaDDC* involved in tyrosine-induced cuticle tanning in Japanese pine sawyer beetle, *Monochamus alternatus*

Jiyun Wi[1], Seulgi Mun[2], Yasuyuki Arakane[2] and Mi Young Noh[1]
[1]Department of Forest Resources, Chonnam National University
[2]Department of Applied Biology, Chonnam National University

In insects, tanning is a complex and vital physiological process in cuticle coloration (pigmentation) and hardening (sclerotization). With tyrosine as the initial substrate, the early steps in the tanning pathway are the hydroxylation of tyrosine to produced 3,4-dihydroxyphenylalanine (DOPA) by tyrosine hydroxylase (TH), followed by the decarboxylation of DOPA to dopamine by DOPA decarboxylase (DDC). In this study, we report the physiological functions of MaTH and MaDDC from Japanese pine sawyer beetle, *Monochamus alternatus*, which is a major vector of the pinewood nematode, *Bursaphelnchus xylophilus* that causes Pine wilt disease. We identify, clone and characterize the *MaTH* and *MaDDC* cDNAs. Loss of function(s) of *MaTH* and *MaDDC* by RNA interference (RNAi) causes abnormally pale/white and light yellow-brown cuticle color of *M. alternatus* adults, respectively. These results indicate that both MaTH and MaDDC play critical roles in normal cuticle coloration of *M. alternatus* adult.

P71

Identification and function of molting fluid chitinases in the Japanese pine sawyer beetle, *Monochamus alternatus*

Youngseo Lee[1], Seulgi Mun[2], Yasuyuki Arakane[2] and Mi Young Noh[1]
[1]Department of Forest Resources, Chonnam National University
[2]Department of Applied Biology, Chonnam National University

Insect cuticle is an extracellular matrix formed primarily from two different biopolymers, chitin and protein. During each molt cycle, a new cuticle is deposited simultaneously with degradation of the old one by molting fluid enzymes including epidermal chitinases. Insect chitinase belongs to family 18 glycosylhydrolase and have been classified into eleven groups based on phylogenetic analysis. In this study, we report a physiological function of molting fluid chitinases from the Japanese pine sawyer beetle, *Monochamus alternatus*, MaCHT5 (group I) and MaCHT10 (group II), including two alternatively spliced isoforms of the later, MaCHT10a and MaCHT10b. RNA interference studies reveal that MaCHT5 is required for both larval-pupal and pupal-adult molts, while depletion of MaCHT10a has little or no effect on those molts. RNAi for both *MaCHT10a* and *MaCHT10b*, however, causes failure of pupation and adult eclosion. These results indicate functional specialization among individual isozymes within each group of chitinases.

P72

Chitin deacetylases are necessary for insect femur muscle attachment and mobility

Seulgi Mun[1], Mi Young Noh[2], Erika R. Geisbrecht[3], Karl J. Kramer[3], Subbaratnam Muthukrishnan[3] and Yasuyuki Arakane[1]
[1]Department of Applied Biology, Chonnam National University
[2]Department of Forest Resources, Chonnam National University
[3]Department Biochemistry and Molecular Biophysics, Kansas State University

Chitin deacetylases (CDAs) plays critical roles in structural integrity and organization of cuticle in insects. In this study, we reveal a novel function of group I CDAs in insect locomotion and muscle attachment using RNAi approach targeted towards specific CDA isoforms in the red flour beetle, *Tribolium castaneum*. Muscle attachment sites (MASs) in insects and other arthropods involve specialized epithelial cells called tendon cells that adhere to the apical extracellular matrices containing chitin. Depletion of TcCDA1 or the alternatively spliced TcCDA2 isoform, TcCDA2a, causes internal tendon cuticle breakage at the femur-tibia joint, muscle detachment from both internal and external tendon cells, and defective locomotion. These results suggest that the absence of *N*-acetylglucosamine deacetylation within chitin leads to a loss of microtubule organization and reduced membrane contacts at MASs in the femur, which adversely affect musculoskeletal connectivity, force transmission and physical mobility.

P73

Immune priming and a lipocalin in a lepidopteran insect, *Spodoptera exigua*

Shabbir Ahmed, Md Tafim Hossain Hrithik, Yonggyun Kim
Department of Plant Medicals, Andong National University

Immune priming is an increased immunity after a prior exposure to a specific pathogen as a kind of adaptive immunity and occurs in insects. However, its underlying mechanisms are elusive in insects. Immune priming was detected in a lepidopteran insect, *Spodoptera exigua*. A prior infection with heat-killed pathogenic bacterium, *Xenorhabdus hominickii*, increased survival upon second infection of the live bacteria compared to larvae without pre-exposure. Plasma collected from larvae with the prior infection significantly up-regulated cellular and humoral immune responses compared to the similar treatment without prior exposure. However, when the active plasma exhibiting immune priming was heat-treated, it lost the priming activity, suggesting a presence of protein factor(s) in the immune priming. Lipocalin is a lipid carrier protein and well known in vertebrates as diverse physiological functions including immunity. An apolipoprotein D3 (ApoD3) is known to be a lipocalin functioning in immune priming in a mosquito, *Anopheles gambiae*. A homologous ApoD3 (Se-ApoD3) was identified in a lepidopteran insect, *Spodoptera exigua*. *Se-ApoD3* was expressed in all developmental stages and in larvae, it was highly expressed in hemocytes. RNA interference (RNAi) of *Se-ApoD3* expression was performed by injecting its specific dsRNA. The plasma collected from RNAi-treated larvae lost the immune priming even at the prior-exposure. These suggest that Se-ApoD3 mediates the immune priming in *S. exigua*.

Key words: Immune priming, Lipocalin, Spodoptea exigua, RNA interference

P74

Genetic variation of chigger mites in Korea

Hyeon Seung Lee[1,2] and Kwang Shik Choi[1,2,3]
[1]School of Life Sciences, College of Natural Sciences, Kyungpook National University, Daegu, Korea
[2]Research Institute for Dok-do and Ulleung-do Island, Kyungpook National University, Daegu, Korea
[3]Research Institute for Phylogenomics and Evolution, Kyungpook National University, Daegu, Korea

털진드기는 매년 4,000명 이상의 환자를 감염시키는 인수공통전염병인 쯔쯔가무시증의 매개체이다. 숙주, 병원체, 매개체 간의 상호작용을 고찰하려면 세 가지의 유전체 정보가 모두 필요하다. 그러나 현재의 털진드기에 대한 연구는 주로 병원체 검출에만 초점을 두고 있으며, 유전적 변이와 DNA/RNA 추출이 용이하지 않은 상당히 작은 크기로 인하여 유전 정보 획득이 어렵고, 또한 털진드기의 분자 데이터는 알려진 종의 수보다 현저히 적은 상태이다. 이에 본 연구에서는 국내 털진드기 분자 데이터 확보를 중점으로 연구를 수행하여 GenBank에 신규 등록한 털진드기 3종(*Leptotrombidium orientale, Neotrombicula gardellai, Eushoengastia koreaensis*)을 포함한 국내 6종 털진드기의 부분적 COI(cytochrome c oxidase subunit I) 서열을 획득하였다. 또한 *Leptotrombidium pallidum*, *Leptotrombidium palpale*, *Leptotrombidium scutellare*에 대한 COI 서열에서 2개 또는 3개의 유전자형이 발견되었지만, ITS2(Internal transcribed speacer 2)에서는 종 내 동일한 유전자형만 발견되었다. 본 연구는 국내 털진드기 COI 염기서열에 유전적 변이가 있음을 발견하였고, 이러한 결과가 생태적 행동 및 질병 전파와 어떤 관련이 있는지를 밝히기 위해서는 추가적인 연구가 필요할 것으로 생각된다.

검색어: Chigger mite, Genetic variation, COI, ITS2

P75

Expression pattern of major royal jelly proteins and defensin-1 in the hypopharyngeal glands of the honeybee *Apis mellifera* upon bacterial ingestion

Yun-Hui Kim[1†], Bo-Yeon Kim[1†], Jin-Myung Kim[1], Yong-Soo Choi[2], Man-Young Lee[2], Kwang-Sik Lee[1*] and Byung-Rae Jin[1*]

[1]College of Natural Resources and Life Science, Dong-A University, Republic of Korea

[2]Department of Agricultural Biology, National Academy of Agricultural Science, Republic of Korea

Transgenerational immune priming (TGIP) to elicit social immunity in the honeybee *Apis mellifera* has two axes: the first is the ingested pathogen fragments–vitellogenin (Vg)–queen's ovary axis for the developing embryo and the second is the ingested pathogen fragments–Vg–nurse's hypopharyngeal gland axis for the queen and young larvae through royal jelly. However, the dynamics of gene expression of major royal jelly proteins (MRJPs) in the hypopharyngeal glands of *A. mellifera* nurse bees upon bacterial ingestion must be determined to better understand the second axis of TGIP. In this study, we investigated the expression patterns of *MRJPs 1–7* and *defensin-1* in the hypopharyngeal glands and *Vg* in the fat body of nurse bees fed with live or heat-killed *Paenibacillus larvae* over 12 h or 24 h by using northern blot analysis. We found that the expression of *MRJPs* and *defensin-1* in hypopharyngeal glands is a pattern similar to the *Vg* expression in the fat body of nurse bees upon bacterial ingestion, indicating that the expression of *Vg*, *MRJPs*, and *defensin-1* was significantly induced, which showed differential expression depending on the bacterial status and time of bacterial ingestion. We also found that antimicrobial peptide genes showed induced expression in young larvae upon bacterial ingestion. In summary, our findings indicate that *MRJPs* are upregulated in the hypopharyngeal glands of nurse bees upon bacterial ingestion, providing novel insights into the ingested pathogen fragments–Vg–nurse's hypopharyngeal gland axis for TGIP.

Key words: *Apis mellifera,* Bacterial challenge, Honeybee, Major royal jelly protein, Vitellogenin

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P76

Dual function of a bumblebee (*Bombus ignitus*) serine protease inhibitor that acts as a microbicidal peptide and anti-fibrinolytic venom toxin

Yun Hui Kim[1†], Bo Yeon Kim[1†], Hyung Joo Yoon[2], Kyeong Yong Lee[2], Hye Kyung Kim[3], Kwang Sik Lee[1*] and Byung Rae Jin[1*]

[1]College of Natural Resources and Life Science, Dong-A University, Republic of Korea
[2]Department of Agricultural Biology, National Academy of Agricultural Science, Republic of Korea
[3]Department of Industrial Entomology, Korea National College of Agriculture and Fisheries, Republic of Korea

In bee venoms, low-molecular-weight peptides, including serine protease inhibitors (SPIs), exhibit multifunctional activities. Although SPIs in bee venoms are relatively well known, those that function in both the body and secreted venom of bees are not well-characterized. In this study, we identified a bumblebee (*Bombus ignitus*) SPI (BiSPI) that displays microbicidal and anti-fibrinolytic activities. BiSPI was found to consist of a trypsin inhibitor–like domain containing a P1 site and ten cysteine residues. We observed that the *BiSPI* gene was ubiquitously transcribed in the body, including the venom glands. In correlation, the BiSPI protein was detected both in the body and secreted venom by using an antibody against a recombinant BiSPI peptide produced in baculovirus-infected insect cells. Recombinant BiSPI exhibited inhibitory activity against trypsin but not chymotrypsin and inhibited microbial serine proteases and plasmin but not elastase or thrombin. Consistent with these inhibitory activities, recombinant BiSPI exhibited microbicidal activities against bacteria and fungi through induction of structural damage by binding to the microbial surfaces. Moreover, *BiSPI* transcription was found induced in the fat body of *B. ignitus* worker bees upon a microbial challenge. Additionally, recombinant BiSPI inhibited the plasmin-mediated degradation of human fibrin and was thus concluded to exhibit anti-fibrinolytic activity. These findings demonstrate the dual function of BiSPI, which acts as a microbicidal peptide and anti-fibrinolytic venom toxin.

Key words: Anti-fibrinolytic agent, Microbicidal agent, *Bombus ignitus*, Bumblebee, Serine protease inhibitor

Acknowledgements: "Cooperative Research Program for Agriculture Science & Technology Development (Project No. PJ01575501)" of the Rural Development Administration, Republic of Korea.

P77

The fumarate effectively recovers the disruption induced by fenpropathrin in silkworm, *Bombyx mori* (Lepidotera) based on metabonomics study

Xue-yang Wang[1,2,3], Mu-wang Li[1,2], Kwang Sik Lee[1], Yang-chun Wu[2,3*] and Byung Rae Jin[1*]

[1]College of Natural Resources and Life Science, Dong-A University, Republic of Korea

[2]Jiangsu Key Laboratory of Sericultural Biology and Biotechnology, School of Biotechnology, Jiangsu University of Science and a Technology, Zhenjiang 212018, Jiangsu, China

[3]The Key Laboratory of Silkworm and Mulberry Genetic Improvement, Ministry of Agriculture, Sericultural Research Institute, Chinese Academy of Agricultural Science, Zhenjiang 212018, Jiangsu, China

The extensive use of pyrethroid pesticides in agriculture has resulted in serious losses in sericulture owing to long-term cross-production. However, the mechanism of silkworm resistance to pyrethroid pesticides is still unclear. Metabolomics is a biological method for bridging the genotype-to-phenotype gap that transcriptomics and proteomics do not, and it has been used to study metabolic responses to environmental changes in silkworms, but not to pyrethroid pesticides. In this study, comparative metabolomics was used to analyze the metabolites of two silkworm strains with varied resistance after feeding with fenpropathrin at various times. A total of 28 metabolites were classified into six metabolic pathways: glycerophospholipid metabolism, sulfur metabolism, glycolysis, amino acid metabolism, urea cycle, and TCA cycle. After analyzing the percentage of change of the metabolic pathways throughout three time periods, the sulfur metabolism, urea cycle, and TCA cycle displayed a substantial reaction to fenpropathrin. Moreover, the primary metabolites in three pathways were then explored to determine the likely metabolic pathway involved in enhancing silkworm tolerance to fenpropathrin, and the combination of Iron(II) fumarate+folic acid (IF-FA) dramatically boosted silkworm resistance by 6.38 times. Furthermore, the affection of fenpropathrin for several energy-related metabolic pathways was verified, and it could be recovered by IF-FA, indicating that IF-FA may have a role in boosting silkworm resistance by modulating the equilibrium between the TCA cycle and its related metabolic pathways. The results of this study will be valuable in clarifying the silkworm's fenpropathrin resistance mechanism as well as effective saving ways for reducing fenpropathrin-induced production loss in sericulture.

Key words: *Bombyx mori*, fenpropathrin, metabonomics, IF-FA, resistant mechanism

P78

Bombyx mori ecdysis hormone receptor B1 can be used as a candidate target for improving silkworm resistance to BmNPV Infection

Zuo-min Shao[1,2], Kang-Sik Lee[1], Xue-yang Wang[1,2,3*] and Byung Rae Jin[1*]

[1]College of Natural Resources and Life Science, Dong-A University, Republic of Korea

[2]Jiangsu Key Laboratory of Sericultural Biology and Biotechnology, School of Biotechnology, Jiangsu University of Science and a Technology, Zhenjiang 212018, Jiangsu, China

[3]The Key Laboratory of Silkworm and Mulberry Genetic Improvement, Ministry of Agriculture, Sericultural Research Institute, Chinese Academy of Agricultural Science, Zhenjiang 212018, Jiangsu, China

Bombyx mori nucleopolyhedrovirus (BmNPV), one of the most serious diseases in sericulture, has caused massive economic losses to silkworm production for its high infectivity. Therefore, it is crucial to study the resistance mechanism to BmNPV, as this will provide theoretical guidance for virus management. *Bombyx mori ecdysis hormone receptor B1* (*BmEcR-B1*) was found to be response to BmNPV infection, whereas the underlying mechanism remains unclear. In this study, the significant difference in expression of *BmEcR-B1* in different tissues of different resistance strains after BmNPV infection 48 h were detected, revealing its important role in virus infection. Moreover, the antivirus role of *BmEcR-B1* was verified using RNAi and overexpression system. Briefly, BV-eGFP proliferation was greatly increased after knockdown of *BmEcR-B1* 72 h, but virus infection was dramatically decreased after *BmEcR-B1* overexpression. Furthermore, *BmEcR-B1* was shown to be the key gene in response to 20-Hydroxyecdysone (20E), and the activation of *BmEcR-B1* by 20E could significantly decrease virus infection and improve silkworm larvae survival rate. A further study revealed that this phenomenon is related to the activation of apoptosis. Finally, the indistinguishable affect of 20E on silkworm larvae development and quantity of silk revealed it had a great value in controling BmNPV in production. The results of this study lay a foundation for clarifying the mechanism of silkworm resistance to BmNPV infection and breeding resistant strains.

Key words: *Bombyx mori*, BmNPV, *BmEcR-B1*, 20-hydroxyecdysone, apoptosis, immune response

P79

Establishment of diagnostic doses of the onion thrips, *Thrips tabaci*, and selection of resistance-related genes via transcriptome analysis

Jong Hyeok Lee[1], Kyungjae Andrew Yoon[2] and Si Hyeock Lee[1, 2]

[1]Department of Agricultural Biotechnology, Seoul National University, Seoul 151-921, Republic of Korea
[2]Research Institutes for Agriculture and Life Sciences, Seoul National University, Seoul, Republic of Korea

The onion thrips, *Thrips tabaci* (Thysanoptera: Thripidae) is a global pest that causes serious damage to Allium crop species and acts as a vector for iris yellow spot virus (IYSV). Resistance of onion thrips to pyrethroids, carbamates, and spinosyn has been reported for past 30 years but no detailed resistance studies have been conducted. To establish the insecticide-susceptible and resistant strains, relative susceptibilities of 14 regional thrips populations to five representative insecticides (acetamiprid, chlorfenapyr, cyantraniliprole, emamectin benzoate, and spinetoram) were determined and compared by the residual contact vial (RCV) bioasssay using field recommendation doses. Three populations showing relatively more susceptible to all the five insecticides were combined and established as an insecticide-susceptible strain. Using this tentative susceptible strain, diagnostic doses for the five insecticides were determined for on-site resistance monitoring based on RCV. Two populations exhibiting relatively high levels of resistance to emamectin benzoate (EB) were combined and further selected with EB to establish an EB-resistant (EB-R) strain. To identify and select the resistance-related genes, transcriptome analysis was conducted with whole body, head, and abdomen tissues of EB-R. None of the single nucleotide substitutions previously known to be associated with resistance were observed in insecticide target genes including acetylcholinesterase, GABA-receptor, voltage-sensitive sodium channel, glutamate-gated chloride channel, and nicotinic acetylcholine receptor, suggesting that target site insensitivity may not be mainly involved in resistance. Therfore, metabolic factors such as cytochrome P450 (CYP450) and glutathione S-transferase (GST), which showed significantly high expression levels among all of the detoxification factors, might play an important role in development of resistance.

Key words: *Thrips tabaci*, insecticide resistance, diagnostic dose, transcriptome analaysis, detoxification factors

P80

Effect of lysis time on DNA extraction for DNA barcoding

Hyemi Park, Soeun Shin and Youngjin Park
Plant Quarantine Technology Center, Animal and Plant Quarantine Agency

검역 과정에서 검출된 해충은 분류 및 동정은 중요한 과정이다. 검출된 해충 가운데 미성숙태의 해충은 형태적인 동정이 어려워, DNA 바코드 분석으로 동정이 이루어진다. DNA 바코드 분석과정은 DNA 추출과 PCR, 염기서열 분석과정으로 구성이 된다. 이러한 일련의 절차에서 DNA 추출 과정에서 조직 lysis 시간이 차지하는 부분은 3시간에서 최대 24시간이 소요된다. 조직 lysis 추출 시간을 줄일 수 있다면 염기서열 분석시간을 크게 단축시킬 수 있다. 본 연구에서는 분류군별 해충 시료(나비목 열대거세미나방, 파리목 호박꽃과실파리, 벌목 붉은불개미)을 대상으로 시료의 lysis 시간을 3시간 미만으로 두었을 때, 추출시간이 DNA 추출농도에 미치는 영향을 확인하였다. 그 결과, 각각의 lysis 시간별로 추출된 DNA의 농도는 다양하였고, 30분에서 1시간 동안 lysis 시킨 조직에서 추출된 DNA도 염기서열 분석에 활용할 수 있었다,

검색어: DNA 바코드, 조직 lysis, 열대거세미나방, 호박꽃과실파리 , 붉은불개미

P81

Change of the honey bee, *Apis mellifera*, colony weight and transcriptional level of the immune-related genes in different thermal conditions during winter

Kyungmun Kim, Bo-Sun Park, Ju-Gyeong Kim, Eun-Jin Kang and Dongwon Kim
Apiculture Division, Department of Agricultural Biology, National Institute of Agricultural Sciences, RDA, Wan-ju 55365, Republic of Korea

Winter is the most harsh season to honey bee but they should endure cold weather for the next year's life. To understand honey bee physiology according to the thermal condition during winter, we placed the colonies outdoors and in warehouses where the temperatures are different (1 and 4°C). Colonies that wintered indoors showed less decreased rate of the colony weight (10.71% - 13.19%) than that of the colonies wintered outdoors (13.93% - 14.63%). Transcriptional expression patterns of the honey bee immune-related genes during winter were investigated. Transcriptional level of the *superoxide dismutase, catalase, prophenoloxidase, hymenoptaecin, abaecin, apidaecin, defensin2, methylfarnesoate epoxidase* had been suppressed until early Mar. and drastically increased after the bees awaken for spring. On the other hand, transcriptional level of the *Def1* was gradually up-regulated during winter and then down-regulated after wintering is over.

Key words: *Apis mellifera*, overwintering, colony weight, immune-related genes

P82

Characterization of anti-microbial peptides from larvae of Calliphoridae and Sarcophagidae species

Kyungjae Andrew Yoon[1], Woo-Jin Kim[2], Hanna Cho[3], Hyeokjun Yoon[3], Byoung-Hee Lee[3] and Si Hyeock Lee[1,4]

[1]Research Institute of Agriculture and Life Sciences, Seoul National University, Seoul 08826, Korea
[2]EntoCode Co., Seoul 06028, Korea
[3]Biological and Genetic Resources Assessment Division, National Institute of Biological Resources, Incheon 22689, Korea
[4]Department of Agricultural Biology, Seoul National University, Seoul 08826, Korea

Removal of infected wound tissues by maggots has been known for centuries, and early researches have shown that larval exosecretion, whole body, and fecal waste products of Calliphoridae and Sarcophagidae species contain a variety of alkaline peptides, which inhibit bacterial growth. Since the wide application of antibiotics such as penicillin as a medicine, hugh ratio of bacterial infections have been insensitive to antibiotic treatment and the larval therapy has been successfully applied for treatment of chronic wounds. To identify and compare the biological activities of anti-microbial peptides from the larvae of some dipteran species, cecropin A2 and defensin, which showed the highest expression level among anti-microbial peptides, were synthesized. The synthesized peptides showed anti-microbial activities without any hemolytic activities. In particular, cecropin A2 of *Lucilia illustris* exhibited highest anti-microbial activity against all bacteria and fungi examined, thereby possessing a potential to be developed as a new alternative to antibiotics. This comparative and functional study of anti-microbial activities may provide new insights into bio-active compositions in some dipteran larval species.

Key words: anti-microbial activity, anti-microbial peptide, calliphoridae, sarcophagidae, larvae

P83

Study on PBAN receptor and its characteristics in *Spodoptera frugiperda*

Youngjin Park and Gokulanathan Anandapadmanaban
Plant Quarantine Technology Center, Animal and Plant Quarantine Agency

We explored the expression level of *Spodoptera frugiperda PBAN receptor*(Sf-PBANr) gene and fecundity of adult females using RNA interference (RNAi) to PBANr gene. The Sf-PBANr was cloned from transcriptome data of *S. frugiperda* and expressed throughout all developmental stages and some tissues in *S. frugiperda*. Specific suppression of Sf-PBANr by RNAi was significantly reduced the total number of eggs laid per adult. Further more mated female adults showed a 63.3% of reduction when adult both male and female pupae were injected dsRNA to SF-PBANr compared with the control. These results indicate that the Sf-PBANr is related to PBAN binding for pheromone biosynthesis.

Key words: *Spodoptera frugiperda*, PBAN receptor, RNA interference, fecundity.

P84

Genetic comparisons of fall armyworm population for quarantine application using SNP markers

Sohee Kim, Hyun-jik Lee, Seonwoo Lee, Soo-Jung Suh and Jong-Ho Lee
Animal & Plant Quarantine Agency, Gimcheon 39660, Republic of Korea

The fall armyworm, *Spodoptera frugiperda* (J.E. Smith, 1797) (Lepidoptera: Noctuidae), is the most important economic pest in the Americas and recently has become an invasive pest in Africa. In particular, this pest causes enormous damage to the gracious plants like rice, barley, corn, and sorghum. It was found not only throughout Africa, but also in India, Sri Lanka, Bangladesh, Myanmar, Thailand, and China. In Korea, FAW has been found in Jeju and inland areas of the Korean Peninsula since this pest was first reported on June 2019. In our study, the maternal genotype (mt-DNA haplotype) and Z-chromosome, a sex-related chromosome were used to analyze the population-genotype of FAW found in Korea. In order to trace country of origin and contagion route of FAW, the same genetic loci of foreign samples such as Laos and the United States were compared and analyzed. It was revealed that FAW found in Korea was rice strain which claded with the Laos sample. Obtaining samples from various countries can provide important clues to understanding lineage of FAW and the history of its population genetics.

Key words: *Spodoptera frugiperda,* fall armyworm, Z-chromosome, genotype, population, trace origin

P85

Changes of diapause-associated genes during embryonic development of the silkworm

Chang Hoon Lee, Sang Kuk Kang, Ik Seob Cha, Nam-Suk Kim and Jong Woo Park
Department of Agricultural Biology, National Institute of Agricultural Science, RDA

누에 유전자원의 장기간 보존 연구를 위하여 누에씨의 배자 발생 과정에서 휴면 연관 유전자들의 발현 변화를 분석하였다. 총 5 종류의 유전자(*BmUGTs*, *BmHsp20.8*, *BmCytb5*, *BmKrh-1*, *BmCpr41*)를 선발하였으며, 단식 또는 복식 냉장을 진행한 잠123, 잠124의 누에씨를 사용하였다. 실험 결과 *BmUGTs*는 최청 과정에서 발현량이 점차 증가하는 추세를 보였다. 잠123에서는 최청 12, 13일차에 발현량이 급격이 감소하였으나, 잠124에서는 꾸준히 증가하는 경향을 보였다. *BmHsp20.8*은 잠123, 잠124 모두 최청 과정 7일까지 발현량이 증가하다가 점차 감소하는 경향을 보였으며, 단식 냉장과 복식 냉장 간의 차이는 없었다. *BmCytb5*는 최청 2~3일까지 발현량이 증가하다가 4일부터 부화까지 발현량이 점차 감소하는 경향을 보였다. *BmKrh-1*은 잠123, 잠124 모두 최청 8일째부터 발현량이 급격하게 증가하였으며 잠123, 잠124 간 그리고 단식 냉장과 복식 냉장 사이에 차이는 없었다. *BmCpr41*은 잠123, 잠124 모두 부화 직전에 발현량이 급격하게 증가하였으며, *BmKrh-1*과 마찬가지로 종과 냉장 방법에 따른 차이는 없었다.

검색어: 누에, 장기보존, 휴면 유전자

P86

Genome wide discovery and characterization of coding and long non-coding RNAs involved in diamide resistance in *Spodoptera exigua*

Hwa Yeun Nam[1], Juil Kim[1,2], Ju Hyeon Kim[3], Su Ryeo Park[4] and Si Hyeock Lee[4]
[1]Agriculture and Life Science Research Instiiute, Kangwon National University
[2]Program of Applied Biology, Division of Bio-resource Sciences, CALS, Kangwon National University
[3]Department of Tropical Medicine and Parasitology, College of Medicine, Seoul National University
[4]Entomology Division, Department of Agricultural Biotechnology, CALS, Seoul National University

Since chlorantraniliprole and flubendiamide were first registered in Korea in 2008, diamide insecticide is widely used to control lepidopteran pests, including *Spodoptera exigua*. Previously we reported resistant specific mutation and InDel in ryanodine receptor, RyR, the target site of diamide, possibly involved its resistance. For a more integrated investigation of diamide resistance mechanism, in-house reference genome DB was set using an F1 hybrid of diamide susceptible and resistant strains. Illumina (coverage ~115X) and nanopore (~23.1Gb) platform was applied. About 450Gb and 1,078 Scaffolds of genome draft set (ASM1567961v1). Based on comparing analysis using Chinese reference genome, it corresponds to 32 chromosomes, and the BUSCOs value was 96%. Following transcriptome analysis, some of cytochrome P450 genes were specifically highly expressed in the resistant strain. Also, some GST genes are only highly expressed in the resistant strain. Total 4,310 long non-coding RNAs (lncRNA) were found, and some specific lncRNA (lncRNA_Spodoptera_2711) possibly interact with RyR. Taken together, we hypothesized that diamide resistance due to various factors such as genetic mutation and gene expression regulation, etc.

Key words: *Spodoptera exipua*, diamide, genome, lncRNA, integrated pest management

P87

Invasive hitchhiker pest occurrence and improvement direction of animal and plant quarantine

Philjae Kim, Hee jo Lee, Dayeong Kim, Min-Ji Lee, Yeong-Gyu Ban, Nang-Hee Kim and Dong Eon Kim*
Invasive alien species team, National Institute of Ecology

2018년 8월 대구 군부대 미국산 물자 하역과정에서 붉은배과부거미(*Latrodectus hesperus*)가 처음 발견되어 국내 생물검역에 대한 우려가 제기된 바 있다. 2020년 12월 인천 대형마트에서 판매한 미국산 포도에서 거미류 발견에 대한 민원 신고를 통해 형태 분류동정 및 거미류 바코드 부위 COI을 분석한 결과, 대구 사례와 동일한 붉은배과부거미로 확인되었다. 이에 붉은불개미보다 강한 독성을 지닌 것으로 알려진 붉은배과부거미가 국내 연이어 발견됨에 따라 생물 검역체계 개선 및 전담 인력 증대, 관계 부처 간 협업의 유연화를 통한 신속한 업무 체계 마련 등의 조치가 필요할 것으로 사료된다.

검색어: 붉은배과부거미, COI 분석, 독성, 검역체계

P88

Complete mitochondrial genome of *Cacopsylla burckhardti* (Hemiptera: Psyllidae) and phylogenetic analysis

Ah Rang Kang[1], Min Jee Kim[2], Jeong Sun Park[3], Eu Ddeum Choi[1], Ho-Jin Seo[1], Jang-Hoon Song[1] and Iksoo Kim[3]

[1]Pear Research Institute, National Institute of Horticultural & Herbal Science, Rural Development Administration, Naju, Republic of Korea

[2]Experiment and Analysis Division, Honam Regional Office, Animal and Plant Quarantine Agency, Gunsan, Republic of Korea ivistion of Forest Biodiversity, Korea National Arboretum

[3]Department of Applied Biology, College of Agriculture & Life Sciences, Chonnam National University, Gwangju, Republic of Korea

Cacopsylla burckhardti (Hemiptera: Psyllidae), which is distributed in Korea and Japan is a pest of pear. We sequenced the complete mitochondrial genome (mitogenome; 14,799 bp) of *C. burckhardti* collected in South Korea. The *C. burckhardti* mitogenome consists of a typical set of genes [13 protein-coding genes (PCGs), two ribosomal RNA (rRNA) genes, and 22 transfer RNA (tRNA) genes] and one major non-coding A+T-rich region (662 bp). Phylogenetic analyses using the concatenated sequences of 13 PCGs and two rRNA genes of available mitogenome sequences of Psylloidea in Hemiptera by Bayesian inference method and Maximum-likelihood methods revealed a strong monophyletic group for the genus *Cacopsylla*.

Key words: Mitochondrial genome, *Cacopsylla burckhardti*, Pear

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P89

Rapid and sensitive loop-mediated isothermal amplification assay with a fall armyworm specific gene

A-Young Kim[1], Thu Anh Thi Ha[2], Xuan Linh Mai[2] and Young Ho Koh[1,2]

[1]Ilsong institute of Life Science, Hallym University, Seoul.

[2]Department of Biomedical Gerontology, Hallym University Graduate School, Chooncheon, Gangwon-do.

The fall armyworm [FAW, *Spodoptera frugiperda* (J E Smith)], a moth native to America, has spread throughout the world since it was first discovered in Africa in 2016. The FAW is a polyphagous migratory pest that can travel over long distances using seasonal winds or typhoons because of its excellent flying ability, causing serious damage to many crops. For effective FAW control, accurate species identification is essential at the beginning of the invasion. In this study, the FAW-specific gene Sf00067 was discovered by performing bioinformatics to develop a fast and accurate tool for the species-specific diagnosis of this pest. An Sf00067 loop-mediated isothermal amplification (LAMP) assay was developed, and optimal conditions were established. The Sf00067 6 primer LAMP assay established in this study was able to diagnose various genotype-based strains of FAW captured in Korea and FAWs collected from Benin, Africa. Our FAW diagnostic protocol can be completed within 30 min, from the process of extracting genomic DNA from an egg or a 1st instar larva to species determination. (RDA Grant No. PJ014845)

Key words: fall armyworm, LAMP, genomic DNA, species-specific gene

P90

Optimization of droplet digital PCR assay for detection of low-frequency mutation

Kyung Hwan Moon and Young Ho Kim
Department of Vector Entomology, Kyungpook National University

Digital droplet PCR (ddPCR) is highly sensitive for quantification of the target genes from limiting samples, and it can be also applied for detection of low-frequency mutations. In order to optimize the application method of ddPCR to detect mutation, in this study, efficiency of differently designed probes were compared using plasmid containing G119S mutation of *Haemaphysalis longicornis* acetylcholinesterase 1. The sense probes dually labelled with FAM and HEX for G119 and S119, respectively, were better than anti-sense and single-labelled probe. In addition, mutation site positioned in the center of probe was more efficient than that positioned at the end of probe for detection of G119S.

Key words: digital droplet PCR, mutation, detection, probe, label

P91

Comparative transcriptome analysis of cold-resistance in *Spodoptera exigua*

Su Ryeo Park[1], Ju Hyeon Kim[2], Juil Kim[3], Hwa Yeun Nam[3] and Si Hyeock Lee[1,4]
[1]Department of Agricultural Biotechnology, Seoul National University
[2]Department of Tropical Medicine and Parasitology, College of Medicine Seoul National University
[3]Program of applied Biology, College of Agriculture and Life Sciences, Kangwon National University
[4]Research Institute of Agriculture and Life Sciences, Seoul National University

The Beet armyworm, *Spodoptera exigua* (Hübner), is a major migratory pest with the subtropical or tropical origin and thus known as cold-susceptible. In Korea, however, some *S. exigua* populations have been adapted to overwinter in facility cultivation areas without diapause owing to global warming. Since overwintering (OP) and migratory (MP) populations may differ each other in several traits including insecticide susceptibility it is necessary to distinguish two populations in the field for proper management. In this study a transcriptome analysis was conducted to investigate the genetic differences between OP and MP of *S. exigua*. The putative OP larvae were collected in May, whereas putative MP larvae were collected in July. After laboratory adjustment for the first generation, each was reared under two different temperature conditions (18 °C and 25 °C) to induce physiological change. After 14 days and 30 days, differentially expressed genes (DEGs) and relevant biological processes were compared. A total of 815 and 226 DEGs were identified in temperature comparison in OP and MP, respectively. A gene ontology analysis showed that DEGs were enriched in pathways related to lysosome, peroxisome, cholesterol metabolism, hematopoietic cell lineage, nicotinate and nicotinamide metabolism in OP. In addition, amino sugar and nucleotide sugar metabolism, sphingolipid metabolism and choline metabolism in cancer in MP.

Key words: overwinter, migratory, cold resistance, transcriptome analysis

P92

Validation of stable reference genes for quantitative real-time PCR in the *Varroa* mite, *Varroa destructor*

Joonhee Lee[1], Si Hyeock Lee[1, 2] and Sanghyeon Kim[2]
[1]Entomology Program, Department of Agricultural Biotechnology, Seoul National University
[2]Research Institue of Agriculture and Life Sciences, Seoul National University

In this study, in order to select reliable reference genes for studies on acaricide resistance development in *Varroa* mite, transcription profiles of eight putative reference genes (*NADHD*, *GAPDH*, *eEF1A1*, *eEF2*, *RpL5*, *Actin*, *α-tubulin*, and *Rab1*) following treatment of each of three acaricides (coumaphos, fluvalinate, and amitraz) or across different tissues (cuticle, leg, gut/fat body, and synganglion) were analyzed by quantitative real-time PCR (qPCR) with four reference gene validation programs, BestKeeper, geNorm, NormFinder, and RefFinder. Following acaricide treatment, *eEF1A1* and *NADHD* showed the least variation in their expression levels, while the expression levels of *α-tubulin* and *RpL5* were the most stable across different tissue groups. The fluctuation of vitellogenin gene expression profiles following different reference genes usage highlighted the importance of proper reference gene use. Thus, it is recommended to use *eEF1A1* and *NADHD* as reference genes for the comparison of the effects of acaricide on the whole body, whereas *α-tubulin* and *RpL5* are recommended for investigating the tissue-specific expression profiles of target genes.

Key words: *arroa destructor*, qPCR, reference gene, acaricide, tissue

P93

Butterflies from Baekunbong Peak, Yangpyeong-gun in Korea

Jae-Won Kim, Ji-Hye Park and Yoo-Hang Shin
Yangpyeong Insect Museum

본 연구는 양평곤충박물관 개관 10주년을 기념하여 양평군 곤충상에 대한 최초의 기록인 석주명의 남조선접류채집기를 참고하여 나비상을 비교하고자 실시되었다. 백운봉의 나비류에 대한 조사결과 총 5과 31속 47종 296개체를 확보하였다. 과별 종수는 네발나비과 22종(46.8%), 부전나비과 12종(25.5%), 호랑나비과 7종(14.9%), 흰나비과 및 팔랑나비과 각 3종(6.4%)의 순서로 조사되었다. 석주명의 조사 결과는 총 5과 20속 24종이며, 과별 종수로는 네발나비과 10종(41.7%), 팔랑나비과 7종(29.2%), 부전나비과 4종(16.7%), 흰나비과 2종(8.3%), 호랑나비과 1종(4.2%)의 순으로 나타났다. 석주명과 양평곤충박물관에서 조사된 백운봉의 나비류 총 종수는 5과 41속 61종이며, 과별 종수로는 네발나비과 28종(45.9%), 부전나비과 13종(21.3%), 팔랑나비과 9종(14.8%), 호랑나비과 7종(11.5%), 흰나비과 4종(6.6%)이다.

검색어: 양평군, 백운봉, 나비상, 석주명

P94

Parasitization trend of two larval parasitoids on two *Monochamus* vectors of the pine wood nematode in Pohang, South Korea

Moo-Sung Kim, Il-Kwon Kim and Bong-Woo Lee
Division of Forest Biodiversity, Korea National Arboretum

The damage of the pine wilt disease has been causing tremendous damage on pine trees nationwide since its accidental invasion. Up to date controlling methods largely depend on physical removal and chemical application that often cause negative side effects on environment. From 2018 to 2020, we carried out a study to find potential biological agents and to analyze the relationship between environment variable and parasitism rate of parasitoids from Pohang city where the two *Monochamus* vectors, *M. alternatus* Hope and *M. saltuarius* Gebler, inflicted economic damage on pine trees. Two dominant braconid parasitoids were identified, namely *Spathius verustus* and *Cyanopterus flavator*. The result of regression and correlation analyses showed a significant trend that the parasitism rate of both parasitoids was positively correlated to host density.

Key words: biological control, *Monochamus*, pine wood nematode, parasitoids, parasitism rate

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Effect of several companion plants on longevity of *Orius laevigatus* (Fieber) (Hemiptera: Anthocoridae)

Eun Jung Han, Seung Min Jeong and Seong Nam Oh
Organic Agricultural Division, National Institute of Agricultural Sciences

천적을 활용한 해충관리의 성공을 위해서 천적의 정착을 증진 시킬 수 있는 서식처 관리기술이 필요하다. 본 연구에서는 시설재배지에서 많이 사용되고 있는 미끌애꽃노린재의 정착을 위한 동반식물을 선발하기 위하여 실내에서 수행되었다. 대상 식물인 메리골드(*Tagetes erecta*, 국화과), 익모초(*Leonurus japonicus,* 꿀풀과), 일일초(*Cathanranthus roseus*, 협죽도과), 메밀(*Fagopyrum esculentum*, 마디풀과), 원예용 고추(*Capsicum annuum*, 가지과)의 개화 경과 미 개화 경을 우화24시간 이내의 미끌애꽃노린재 성충과 함께 처리하여 성충의 수명을 무처리구와 비교하였다. 그 결과 익모초, 일일초, 원예용고추의 개화경 처리구에서 무처리구 대비 성충의 수명 증진 효과를 확인할 수 있었으며, 일일초의 경우 미 개화경에서도 성충 수명의 증진을 확인하였다. 본 연구 결과는 익모초, 일일초, 원예용고추가 미끌애꽃노린재 증진을 위한 동반식물로서의 활용 가능성을 보여준다. 향후 대상 식물 처리에 따른 미끌애꽃노린재의 약충 발육기간 및 산란수 변화를 비교할 계획이다.

검색어: 천적, 미끌애꽃노린재, 동반식물

P96

Distribution of two subspecies in *Culex pipiens* complex in the Republic of Korea

Jihun Ryu[1,2] and Kwang Shik Choi[1,2,3]

[1]School of Life Sciences, College of Natural Sciences, Kyungpook National University, Daegu, Korea
[2]Research Institute for Dok-do and Ulleung-do Island, Kyungpook National University, Daegu, Korea
[3]Research Institute for Phylogenomics and Evolution, Kyungpook National University, Daegu, Korea

한국의 도심지역에서 가장 흔하게 볼 수 있는 *Culex pipiens* complex는 아직까지 국내에서는 질병을 일으킨 사례가 없으나 주거지역에서 대량으로 발생하는 종이다. 이들은 특히 미국 전역에 퍼져있는 웨스트나일열(WNV)의 주요 매개체로 알려져 있으며, 한국에 서식하는 *Culex pipiens molestus*와 *Culex pipiens pallens* 역시 매개능을 가진 것으로 알려져 있다. 이러한 매개체에 의한 질병 전파율은 각 종의 매개능에 의해 크게 좌우되지만, 한국의 *Culex pipiens* complex는 외형적 차이를 구분하기 어렵기 때문에 대부분 subspecies 단계까지 구분하지 않고 complex로 보고되고 있거나 *Cx. p. pallens*로 인식되고 있다. 이에 본 연구에서는 총 16개 지역에서 채집을 실시하였으며, 종 특이적 프라이머를 디자인하여 *Culex pipiens* complex 종 분포를 분석하였다. 분석 결과, 채집 표본수가 작은(5개체) 울릉도를 제외한 모든 지역에서 *Cx. p. molestus*와 *Cx. p. pallens*가 함께 채집되었고, 지역별 차이는 있으나 총 1,063개체 가운데 70.1%가 *Cx. p. molestus*로, 29.9%가 *Cx. p. pallens*로 확인되었다. 본 연구는 개발된 분자적 종 동정을 통한 한국에 서식하는 이들의 전국적 종 분포에 대한 결과를 처음으로 보고하는 것으로, *Culex pipiens* complex 종 분포 양상에 관한 기초 정보를 제공할 수 있을 것으로 판단된다.

Key words: *Culex pipiens* complex, *Culex pipiens molestus*, *Culex pipiens pallens*, species specific diagnostics

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Report of insect fauna at Seonginbong in Ulleungdo, 2020

Min Hyeok Won[1,2], Jae Won Choi[1,2], Dong Yeol Lee[1], Woo Jun Bang[1], Min ki Moon[1], Young-Kun Kim[3] and Kwang Shik Choi[1,2,4]

[1]School of Life Sciences, College of Natural Sciences, Kyungpook National University, Daegu, Korea
[2]Research Institute for Dok-do and Ulleung-do Island, Kyungpook National University, Daegu, Korea
[3]School of Applied Biosciences, College of Agriculture & Life sciences, Kyungpook National University, Daegu, Korea
[4]Research Institute for Phylogenomics and Evolution, Kyungpook National University, Daegu, Korea

울릉도 성인봉은 환경이 잘 보전되어있는 원시림으로 해발고도에 따라 식생이 다르게 분포하고 있다. 곤충상 또한 고도별로 다르게 분포되어 있을 것으로 예상되며, 이에 따른 성인봉 곤충상 조사를 수행하였다. 조사는 성인봉에서 2020년 4월, 7월, 8월, 10월에 총 4차례, 저지대(300-500m), 중지대(500-800m), 고지대(800-980m)로 구분하여 진행하였다. 채집방법으로는 등화채집, 함정채집, 당밀유인채집, 쓸어잡기를 사용하였고, 함정채집의 경우 유인제로 돼지고기, 낙지, 당밀 3가지를 사용하였다. 조사결과 전체 11목 111과 221속 225종이 채집되었다. 채집방법별로는 등화채집으로 118종, 쓸어잡기로 107종, 함정채집으로 31종, 당밀유인채집으로 9종 채집되었다. 월별로는 4월에 62종, 7월에 104종, 8월에 109종, 10월에 57종이 채집되었으며, 고도별로는 저지대에서 110종, 중지대에서 120종, 고지대에서 99종이 채집되었다. 본 연구를 통해 울릉도 성인봉의 시기별 및 고도별 곤충상을 알아보았고, 이러한 결과는 차후 울릉도 곤충상 연구의 기초자료로 제공될 수 있을 것으로 기대된다.

검색어: Ulleungdo, Seonginbong, insect fauna, altitude, species diversity

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Plasmodium vivax retention rate and species diversity of *Anopheles* mosquitoes in the northwestern part of Korea

So Youn Lee[1,2], Heung Chul Kim[3], Terry A. Klein[3] and Kwang Shik Choi[1,2,4]

[1]School of Life Sciences, College of Natural Sciences, Kyungpook National University, Daegu, Korea
[2]Research Institute for Dok-do and Ulleung-do Island, Kyungpook National University, Daegu, Korea
[3]Force Health Protection and Preventive Medicine, Medical Department Activity-Korea/65th Medical Brigade, Unit 15281, APO AP 96271-5281, USA
[4]Research Institute for Phylogenomics and Evolution, Kyungpook National University, Daegu, Korea

한국에서는 매년 300건 이상의 말라리아 환자가 발생하고 있으며, 이는 주로 DMZ 인근 강원도와 경기도에서 보고되고 있다. 본 연구는 한국의 서북부 지역의 8곳에서 Mosquito Magnets®을 사용해 2020년 5월부터 11월까지 채집한 *Anopheles* 속 모기의 종 다양성과 *Plasmodium vivax* 보유율을 조사했다. 총 1,864마리의 *Anopheles* 속 모기가 채집되었으며, *An. pullus* (32.5%), *An. kleini* (27.4%), *An. sineroides* (20.9%), *An. sinensis* (11.4%), 기타 (7.9%)를 차지하였다. 전체 개체수는 5월부터 점차 증가해 6월에 가장 높았다가 점차 감소 이후, 9월에 다시 증가했다. 월별로는 5월에 *An. pullus*와 *An. sineroides*가 전체의 81.5%를 차지하다가 점차 감소하였고, 6월부터는 *An. kleini*의 비율이 증가해 7월에 정점을 보인 뒤 급격히 줄었다. 채집한 개체 중 *P. vivax*에 감염된 개체는 총 36마리로, 이 중 *An. kleini*에서 9마리가 검출되었으며, *An. belenrae* (8), *An. pullus* (8), *An. sinensis* (5), *An. sineroides* (5), *An. lindesayi* (1) 순으로 확인되었다. 본 연구는 한국의 말라리아 위험지역에서 *Anopheles* 속의 시기별 종 분포와 *P. vivax* 감염률을 조사하였고, 처음으로 *P. vivax*에 감염된 *An. lindesayi* 개체를 보고하고자 한다. 이러한 결과는 향후 말라리아 매개체 관리에 대한 방향을 제시하는 참고자료로 활용할 수 있을 것으로 기대된다.

검색어: malaria, *Anopheles*, *Plasmodium vivax*, Mosquito Magnet, DMZ

P99

Flight ability of the *Callipogon relictus* Semenov on flight mill

Jun-Young Kang, Da Jeong Son, Gyu Young Han, Bong-Woo Lee and A-Young Kim
Divistion of Forest Biodiversity, Korea National Arboretum

Callipogon relictus, natural monument No. 218, is an insect that has many difficulties in restoration and conservation as the exact ecology is not known until now. The Korea National Arboretum conducted flight mill experiment to understand ecological characteristics such as the ability to flight and dispersal of *C. relictus* inhabiting in Gwangneung forest. An experiment was performed to confirm the flight ability of the *C. relictus* adults using a flight mill that measures flight distance, time, and velocity. The individuals tested in this study were unmated and had been more than 2 weeks after emergence. As a result of the experiment, it was confirmed whether there were differences in flight abilities according to the sex, body length and weight.

Key words: *Callipogon relictus*, flight mill, ecological study, dispersal capacity

P100

Detection of potato insect pests in the areas at 38° north latitude

I Hyeon Kim[1], Eun Young Kim[1], Bo Yoon Seo[2] and Jin Kyo Jung[1]
[1]Crop Cultivation and Environment Division, Natl. Institute of Crop Science
[2]Crop Foundation Division, Natl. Institute of Crop Science

국내 북위 38° 부근의 서쪽의 백령도(124°E)와 중앙의 연천(127°E), 동쪽의 고성(128°E)에서 2020년과 2021년에 걸쳐 감자포장에서 진딧물을 중심으로 해충들을 채집하고 종류를 동정하였다. 채집된 곤충들에 대해서는 시토크롬 옥시다제 1 유전자의 부분염기서열을 비교하여 종을 동정하였다. 진딧물 종에는 목화진딧물과 복숭아혹진딧물이 우점하였고, 그 밖에 감자수염진딧물, 싸리수염진딧물, 기장테두리진딧물, 붉은테두리진딧물, 잠두진딧물, 느티나무알락진딧물, 붉나무소리진딧물, *Capitophorus* sp.가 발견되었다. 백령도와 고성에서는 큰28점박이무당벌레에 의한 잎 피해가 심한 포장이 발견되었다. 고성의 한 포장에서는 목화진딧물과 복숭아혹진딧물, 큰28점박이무당벌레가 동시에 고밀도로 발생하면서 감자 갈색점무늬병(*Alternaria alternata*)(추정) 피해가 심한 포장이 발견되었다. 이외에 도둑나방 알과 유충이 발견되었으나 피해 현상은 뚜렷하게 관찰되지 않았다. 진딧물과 도둑나방 알에서 기생벌 몇 종이 발견되었다.

검색어: 고위도지역, 감자 해충, 유전자 동정, 진딧물류, 큰28점박이무당벌레

P101

Population genetic characterization of the endangered dung beetle *Copris tripartitus* (Coleoptera: Scarabaeidae) using novel microsatellite markers

Min Jee Kim[1,2†], Su Yeon Jeong[1†], Sung-Soo Kim[3], Jun Seong Jeong[1], Jong Seok Kim[1], Heon Cheon Jeong[4], Ki-Gyoung Kim[5] and Iksoo Kim[1*]
[1]Department of Applied Biology, College of Agriculture & Life Science, Chonnam National University
[2]Experiment and Analysis Division, Honam Regional Office, Animal and Plant Quarantine Agency
[3]Research Institute for East Asian Environment and Biology
[4]Korea Native Animal Resources Utilization Convergence Research Institute, Soonchunhyang University

In this study, we developed ten microsatellite markers specifically for *C. tripartitus*. Sixty-eight individuals of *C. tripartitus* collected from six South Korean localities were genotyped to validate these markers and preliminarily assess population genetic characteristics. All populations showed higher H_O than H_E, negative values of inbreeding coefficient, and, overall, no sign of recent population bottlenecks (excluding one population, Seosan). This suggests that *C. tripartitus* did not suffer from genetic drift and inbreeding, which are typically severe in small, isolated populations. Nevertheless, detection of only one of the two gene pools in some populations and resultant genetic subdivision into two population groups may suggest that the population size is not enough to cover both gene pools.

Key words: Dung beetle, Endangered species, Microsatellite DNA, Molecular marker, Conservation

†These authors equally contributed to this study.

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A study on reconnect possibility by the capture and recapture survey of ground beetles on Eco-corridor

Seong Nam Oh[1], Eun Jung Han[1], Dong Gul Woo[2*] and Jong Kyun Park[3*]
[1]Organic Agricultural Division, National Institute of Agricultural Sciences
[2]National Institute of Ecology
[3]College of Ecology and Environmental Science, Kyungpook National University, Sangju, Korea

백두대간 내 추풍령 구간에 3개의 생태통로가 완공됨에 따라 야생동물의 단절된 서식지의 연결이 기대되고 있다. 본 연구에서는 딱정벌레아과 3종을 대상으로 Capture & recapture 실험을 실시하여 지표성 딱정벌레류의 생태통로 이용 가능성을 평가하였다. 3개의 생태통로 좌측에 차량용 페인트로 마킹된 멋쟁이딱정벌레(75개체), 우리딱정벌레(50, 51, 51개체), 민줄딱정벌레(1개체)를 각각 방생하고 재포획을 실시하였다. 그 결과 생태통로 1 상부와 생태통로 3 상부, 우측에서 멋쟁이딱정벌레가 각각 4개체, 2개체, 1개체 재포획되었다. 방생한 개체가 생태통로 상부, 우측에서 일부 재포획되었으므로 생태통로를 이용한 단절된 서식지의 연결가능성을 확인하였다. 하지만 특정 서식지 선호도가 없는 멋쟁이딱정벌레와 달리 산지 서식지를 선호하는 우리딱정벌레, 민줄딱정벌레는 재포획되지 않았기 때문에 생물종의 서식지 선호도 여부가 생태통로 이용에 영향을 준다고 생각된다. 따라서 다양한 종들이 생태통로를 이용하기 위해서는 완공 후 식생의 유입과 주변 서식지 환경과의 동질화에 필요한 충분한 시간이 요구될 것으로 판단된다.

검색어: 생태통로, 추풍령, 딱정벌레, 함정트랩, 서식지

P103

Comparison on the voltinism of *Bactrocera dorsalis* and *Zeugodacus cucurbitae* in Taiwan

Jeong Joon Ahn[1], Kyoung San Choi[1] and Yu-Bing Huang[2]
[1]Research Institute of Climate Change and Agriculture, National Institute of Horticultural and Herbal Science, RDA
[2]Taiwan Agricultural Research Institute, Taichung, Taiwan (R.O.C)

The oriental fruit fly *Bactrocera dorsalis* and the melon fruit fly *Zeugodacus cucurbitae* are major invasive and polyphagous insect pests with a worldwide distribution. We investigated the voltinism (the number of generations) of *B. dorsalis* and *Z. cucurbiate* in Taiwan and Korea. Determinig the voltinism obtained based on the climate data and developmental parameters (lower developemntal threshold LTD and thermal constant K) is useful to estimate the establishment potential for invasive species. We used the LTD and K of both species for estimating voltinism in 10 and 12 locations of Taiwan and Korea. The number of voltinism in Taiwan was higher than that in Korea.

Key words: *Bactrocera dorsalis*, *Zeugodacus cucurbitae,* Lower developmental threshold, thermal constant, voltinism

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Effects of CO_2 concentration on the development model of *Riptortus pedestris* (Fabricius) (Hemiptera: Alydidae)

Jeong Joon Ahn and Hyeonseok Oh
Research Institute of Climate Change and Agriculture, National Institute of Horticultural and Herbal Science, RDA

The global atmospheric concentration of carbon dioxide has risen about 35% from the preindustrial period and is increasing continuously as the results of anthropogenic activities. The bean bug, *Riptortus pedestris,* is a polyphagous and one of the most important pests in soybean fields. Both adults and nymphs of *R. pedestris* feed on leguminous plants and attack the soybean pod and seed by piercing and sucking. In this study, we collected detailed data on development periods of *R. pedestris* under four different CO_2 concentrations, 400, 600, 1000 and 1500 ppm. We constructed CO_2 concentration-dependent development model of *R. pedestris.*

Key words: *Riptortus pedestris,* Carbon dioixde, Development, Modelling

Acknowledgements: This research was supported by the research program of RDA (PJ01206002).

P105

Effects of CO_2 concentration on the oviposition model of *Riptortus pedestris* (Fabricius) (Hemiptera: Alydidae)

Jeong Joon Ahn and Hyeonseok Oh
Research Institute of Climate Change and Agriculture, National Institute of Horticultural and Herbal Science, RDA

The bean bug, *Riptortus pedestris,* is an economically important insect pest of soybean. We investigated the CO_2 concentration effects on the adult longevity and female fecundity of *R. pedestris*. The study conducted under five different CO_2 concentrations, 400, 600, 1,000, 1,500 and 2,000 ppm, respectively. *R. pedestris* females reproduced successfully under all tested CO_2 levels. Oviposition model was constructed by adult aging rate, age-specific survival, age-specific cumulative oviposition rate and temperature dependent total fecundity models as temperature-dependent oviposition model.

Key words: *Riptortus pedestris,* Carbon dioixde, Fecundity, Longevity, Oviposition model

Acknowledgements: This research was supported by the research program of RDA (PJ01206002).

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Effects of CO_2 concentration on the development model of *Myzus persicae* (Sulzer) (Hemiptera: Aphididae)

Jeong Joon Ahn and Kyoung San Choi
Research Institute of Climate Change and Agriculture, National Institute of Horticultural and Herbal Science, RDA

The green peach aphid, *Myzus persicae*, is one of the significant aphid pests of several crops, damaging various tissues of plants, and acting as a vector for the transport of plant viruses. We investigated the effect of CO_2 concentration on development of *M. persicae* under three different CO_2 concentrations, 400, 600, and 1,000 ppm, respectively. In this study, we collected detailed data on development periods of *M. persicae* under three different CO_2 concentrations. We constructed CO_2 concentration-dependent development model of *M. persicae* and the adult emergence frequency over the full range of CO_2 concentrations was simulated.

Key words: *Myzus persicae,* Carbon dioixde, Development, Modelling

Acknowledgements: This research was supported by the research program of RDA (PJ01606001).

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Effects of CO_2 concentration on the oviposition model of *Myzus persicae* (Sulzer) (Hemiptera: Aphididae)

Jeong Joon Ahn and Kyoung San Choi
Research Institute of Climate Change and Agriculture, National Institute of Horticultural and Herbal Science, RDA

We evaluated the direct effect of three different CO_2 concentrations (400, 600 and 1,000 ppm) on the longevity and fertility of green peach aphid, *Myzus persicae* for constructing CO_2 concentration-dependent oviposition model, while being fed on cabbage. We investigated the adult longevity and fertility of *M. persicae* under three different CO_2 concentrations. Oviposition model was constructed by adult aging rate, age-specific survival, age-specific cumulative oviposition rate and temperature dependent total fecundity models as temperature-dependent oviposition model. The daily nymph production was simulated with respect to CO_2 concentration and adult age.

Key words: *Myzus persicae*, Carbon dioixde, Fecundity, Longevity, Oviposition model

Acknowledgements: This research was supported by the research program of RDA (PJ01606001).

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Occurrence of *Chilo suppressalis* (Crambidae) and rice damage in northern China

Jin Kyo Jung[1], Eun Young Kim[1], Woonho Yang[1], Seuk-ki Lee[1], Myeong Na Shin[1], Jung-Wook Yang[1], Hongguang Ju[2], Dongcun Jin[2], Jin Pao[2], Jichun Wang[3] and Feng Zhu[3]

[1]Crop Cultivation and Environment Division, Natl. Institute of Crop Science, RDA

[2]Department of Agronomy, Yanbian University, China

[3]Institute of Plant Protection, Jilin Academy of Agricultural Science, China

북위도 40-43°대에 위치한 중국 단둥(40°)과 룽징(42°), 궁주링(43°) 지역에서 2020년과 2021년 5~9월 사이에 이화명나방 성충의 밀도변동 양상을 트랩을 이용하여 조사하였다. 1화기 성충 발생은 5월 중순~7월 하순에, 2화기 성충 발생은 7월 초순~9월 하순 사이에 관찰되었다. 위도가 높아질수록 발생시기가 늦어졌다. 1화기 발생기간을 기준으로, 발생시기 예측 모델로 2화기 발생 시기를 추정하였을 때, 유충 발육속도가 빠른 자료로 구축된 모델에서의 추정 시기가 관찰 시기와 가까운 경향이었다. 벼 피해주율은 성충 발생 피크가 나타난 시기 직후 바로 나타났고, 성충 2세대 발생기간 동안 계속 증가하여, 최고 약 35%까지 관찰되었다.

검색어: 이화명나방, 중국 북쪽지역, 성충 발생 시기, 세대진전 추정, 벼 피해시기

P109

Detection of migratory lepidopteran species, *Mythimna separata*, *M. loreyi* and *Spodoptera frugiperda*, using sex pheromone traps in the areas at 38° north latitude

Ji Hyun Lee[1], Eun Young Kim[1], Bo Yoon Seo[2] and Jin Kyo Jung[1]

[1]Crop Cultivation and Environment Division, Natl. Institute of Crop Science

[2]Crop Foundation Division, National Institute of Crop Science

비래해충인 멸강나방과 열대거세미나방 및 비래성으로 추정되는 뒷흰가는줄무늬밤나방이 국내 고위도 지역에 발생하는가를 알기 위해, 북위 38° 부근의 백령도(124°E)와 연천(127°E), 고성(128°E)에서 2020년과 2021년에 성페로몬트랩으로 이들의 발생을 탐지하였다. 포획된 곤충들은 생식기 형태와 유전자 서열 비교로 종을 동정하였다. 열대거세미나방은 고성에서 탐지되지 않았고, 다른 두 종은 세 지역 모두에서 탐지되었다. 뒷흰가는줄무늬밤나방 성충은 백령도에서 2020년 6월 초 매우 짧은 기간 동안 포획 수가 급격하게 증가한 후 다시 급격하게 감소한 현상이 관찰되어, 이 곤충도 비래성으로 판단되었다. 단 고성에서의 발생은 해당 시기 비래한 것인지 뚜렷하지 않았다. 각 트랩에 같이 포획된 비표적종들 중 *Mythimna*속 나방류와, 회양목명나방, 맵시곱추밤나방을 포함한 몇 종은 해당 종의 트랩 미끼에 유인된 것으로 추정되었다.

검색어: 멸강나방, 뒷흰가는줄무늬밤나방, 열대거세미나방, 고위도지역, 발생탐지

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Faunal inventory of the insect on the Is. Yokji-do, Prov. Kyungnam and Is. Wan-do, Prov. Jeonnam Prov., Korea

Da-Som Kim[1], Dong-Myoung Kim[2], Jin-Sung Kweon[2], Seung Jin Roh[3], Dong-Jun Lee[3] and Bong-Kyu Byun[2]
[1]National Science Museum, Daejeon, Korea
[2]Department of Biological Science and Biotechnology, Hannam University, Korea
[3]Divistion of Zoology, Honam National Institute of Biological Resourse

본 연구는 호남권 섬 지역 조사를 통해 다양한 자생생물(동물분야)의 분포정보를 확보하고 그동안 발굴되지 못한 생물 종 및 점차 변화될 생물종 다양성을 확인하는 연구를 위한 기초자료를 확보하기 위해 수행되었다. 2021년의 조사지역은 경남 욕지도 및 전남 완도 일대이다. 현지조사는 주요 곤충류가 출현하는 시기인 7월부터 10월까지 3회에 걸쳐 집중적으로 채집조사를 실시하였으며, 세부적인 조사지점은 해당지역을 순회하면서 식생이 양호하고 채집이 용이한 지역을 고려하였다. 주간에는 포충망을 이용한 관찰채집을 실시하였으며 야간에는 유아등을 이용한 등화유인채집과 버킷식 유아등 트랩을 이용하였다. 현지조사를 통하여 채집된 곤충은 건조표본으로 제작하여 종 수준까지 분류 및 동정 작업을 수행하여 총 29과 176종 511개체의 나방류, 딱정벌레류 및 노린재류가 채집조사되었다. 금번연구를 통해 밝혀진 섬지역 곤충다양성 조사결과는 향후 섬지역 생물다양성 및 생물지리학적 연구를 위한 기초자료로 활용될 것으로 기대된다.

검색어: 호남권, 섬지역, 채집조사,동정, 분포

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Plant visiting insect inventories in the major arboreta in Korea

Jun-Min Seo[1], Shin-Gu Kang[2], Kee-Hwa Bae[2], Jong-Woo Nam[2], Jae-Ho Ko[3], Ju-Hee Lee[2], Ji-Young Lee[1], Jae-In Oh[1], Sang-Yoon Kim[1], June-Hyeok Jeong[1], So-Yeon Kim[1], Soo-Jeong Park[1], Dong-Myoung Kim[1], Jin-Sung Kweon[1] and Bong-Kyu Byun[1]
[1]Department of Biological Science and Biotechnology, Hannam University, Korea
[2]Divistion of Forest Biodiversity, Sejong National Arboretum, Korea
[3]DASARI Research Institute of BioResources, Korea

전 세계적으로 식물에 방문하는 화분매개동물을 포함한 방문생물 분야에 대한 연구는 많이 수행되고 있지만, 통합적인 접근체계에 대한 연구는 전무한 상황이다 (강, 2021). 본 연구는 생태계를 대표하는 국내 권역별 수목원의 전반적인 곤충상을 계절에 따라 모니터링 함으로써, 우리나라 생태계의 현 위치를 파악하고 보전의 방향성을 제시하기 위해 수행되었다. 조사방법은 국내 9개소 수목원을 대상으로 2021년 5월부터 9월까지 봄(5월), 여름(7월) 및 가을(9월) 총 3회에 걸쳐 목표 식물을 대상으로 스위핑(Sweeping) 및 비행간섭트랩을 설치하여 실시하였다. 이를 통해 85종의 식물을 대상으로 총 9목 129과 568종 4,195개체의 곤충을 채집 및 동정을 수행하여 곤충상 자료를 구축하였다.

검색어: 생물다양성, 화분매개, 곤충상, 방문생물, Pollinator, Biodiversity

P112

Lepidopterous insect fauna of Boeun, Chungcheongbuk-do and Sangju, Gyeongsangbuk-do, Korea

Soo-Jeong Park, Ji-Young Lee, So-Yeon Kim, Jun-Min Seo and Bong-Kyu Byun
Department of Biological Science and Biotechnology, Hannam University, Korea

본 조사는 제5차 전국자연환경조사의 일환으로 육상곤충류의 분포현황을 알아보기 위해 수행되었다. 충청북도 보은군(회북, 보은, 관기 도엽)과 경상북도 상주시(화서, 신촌, 상주 도엽)를 각각 3개 도엽씩 구분하여 최소 2계절 이상 포함되도록 2021년 5월부터 9월까지 총 24회(도엽당 4회)의 채집·조사를 실시하였다. 조사방법으로는 포충망을 이용한 쓸어잡기, 채어잡기 및 현장확인 등을 통해 기본조사를 수행하였으며, 트랩 조사방법으로는 버킷라이트트랩을 사용하였다. 현지조사를 통해 채집된 곤충은 건조표본으로 제작하여 종 수준까지 분류 및 동정 작업을 수행하여 총 33과 329종 1,094개체의 육상곤충류가 채집·조사되었다. 2018년 수행된 선행조사에서는 37과 607종의 육상곤충류가 확인되었으며 선행 조사 결과와 금번 현지 조사종을 종합하면, 충청북도 보은군과 경상북도 상주시의 나비목은 총 46과 767종으로 정리되었다. 이 중 31과 280종이 금번 현지조사에서 새롭게 확인된 종이었으며, 앞으로의 조사에서도 다수의 신규 추가종이 확인될 것으로 보여진다.

검색어: 2021년 전국자연환경조사, 육상곤충류, 버킷라이트트랩

P113

Population genetic characterization of the common grass yellow butterfly, *Eurema mandarina* (Lepidoptera: Pieridae), which is a climate-sensitive indicator species

Jeong Sun Park[1], Min Jee Kim[1,2], Heon Cheon Jeong[3], Sung-Soo Kim[4] and Iksoo Kim[1*]
[1]Department of Applied Biology, Chonnam National University
[2]Honam Regional Office, Animal and Plant Quarantine Agency
[3]Korea Native Animal Resources Utilization Convergence Research Institute, Soonchunhyang University
[4]Research Institute for East Asian Environment and Biology, Republic of Korea

The common grass yellow butterfly, *Eurema mandarina* (Lepidoptera: Pieridae), has been designated as a climate-sensitive biological indicator species in Korea. A total of 4,053 single nucleotide polymorphisms (SNPs) was obtained by genotyping-by-sequencing from a total of 65 adults of *E. mandarina* collected across four South Korean localities. Genetic diversity, population genetic characterization, and gene flow estimates consistently indicate typical of range expansion in response to climate change. On the other hand, 42 outlier loci, which are putatively under selection revealed the highest diversity estimates in two inland populations, suggesting that different selection pressures between island populations and inland populations are present, possibly by climate change.

Key words: *Eurema mandarina*, climate-sensitive indicator species, GBS, SNP, adaptation, genetic diversity

P114

The surveillance of chigger mites for *Orientia tsutsugamushi* in Hwaseong-si, Gyeonggi-do, Korea, 2021.

Jae Chan Lee, Dong-In Kim, Yoon Sung Choi, Seung Ha Lee and Hyung Wook Kwon*
Department of Life Sciences & Convergence Research Center for Insect Vectors, Incheon National University

Tsutsugamushi disease transmitted by chigger mites is a seasonal disease of South Korea occurring in autumn. We collected chigger mites from wild rodents in Hwaseong-si and analyzed using nested PCR for detection of *O. tsutsugamushi*. A total of 50 rodents were captured, and the overall trapping rate of the rodents was 12.5%. Among a total of 4653 chigger mites, the mean CI (Chigger mite Index) was 93.06. The monthly CI was highest in April (133.875) and CI of the waterway was highest than other environments. Among 95 tested pools, *O. tsutsugamushi* was detected from 2 pools and was identified as Jecheon stain. In this study, chigger mites existed in both spring and autumn. However, it did not explain that the incidence of scrub typhus has been low in spring for 10 years. We need further studies to find factors such as human behavior and vector biology. It is expected that this study can be used to monitor the occurrence of chigger mites and to develop precautionary measures of tsutsugamushi disease in Korea.

Key words: chigger mite, *Orientia tsutsugamushi*, scrub typhus, surveillance, monitoring

P115

Patterns of insect pests occurrences on Fischer's ragwort in Gangwon Province

Youn Gi Moon[1], Se Won Kim[1], Ki Jin Park[1], Min Ho Lee[2] and Sora Kim[3]
[1]Wild Vegetable Research Institute Gangwon Agricultural Research & Extension Services, Korea
[2]Insect Biosystematics Laboratory, Research Institute of Agricultural and Life Science, Department of Entomology, Seoul National University, Korea
[3]Department of Plant Protection & Quarantine, Jeonbuk National University, Korea

The study was carried out to investigate insect pests and damage caused to the Fischer's ragwort(*Ligularia fischeri*) in Gangwon province during 2016~2021. A total of five order 8 families and 10 species were identified one species of aphid, five species of moth, one species of grasshopper, lace bug, sawfly and fruit fly. Among them, four species caused significant economic damage due to a large number of occurrence; *Aulacorthum ligularicola, Mamestra brassica, Ognevia longipennis*, *Ostrinia zaguliaevi*. *A. ligularicola* started to occur at Pyeongchang from the early of April, and showed the greatest incidence in early May. *M. brassicae, A. takeuchii, C. mormorata, P. dumetana, P. munda* and *O. longipennis* infestation was severe at Pyeongchang from June to July, which is the vegetative season. *M. timida* was severe at Pyeongchang from July to August. *O. hamula* infestation was severe at Pyeongchang from August to September, the flower bud. *O. zaguliaevi* began to occur at Pyeongchang and Inje from early July and damaged flower stalk until mid-October.

Key words: Fischer's ragwort, Insect pests, *Aulacorthum ligularicola, Mamestra brassica, Ostrinia zaguliaevi*

P116

Green tree retention monitoring in Hongcheon and Muju area, Korea

So-Yeon Kim[1], Da-Som Kim[2], Ji-Young Lee[1], Dong-Myoung Kim[1], Jin-Sung Kweon[1], Soo-Jeong Park[1], Jae-In Oh[1], Jun-Min Seo[1], Sang-Yoon Kim[1], June-Hyeok Jeong[1] and Bong-Kyu Byun[1]
[1]Departmant of Biological Science and Biotechnology, Hannam University, Korea
[2]National Science Museum, Daejeon, Korea

우리나라의 친환경벌채 제도는 목재수확 시에 파생되는 산림생태환경의 훼손을 최소화하고 산림의 공익적 기능을 유지하면서 목재를 생산하기 위해 도입되었다. 하지만, 단목으로 남길 경우 나지의 비생물적 환경이 열악해지고 산림의 계층구조가 사라지기 때문에 친환경적 측면의 효과를 기대하기 어렵다는 지적이 대두됨에 따라 친환경벌채지 내 군상잔존구를 설치하여 임분계층구조(미소서식지)를 보호하여 남겨두는 방식으로 전환되고 있다. 따라서, 본 연구는 친환경벌채 법적 제도의 과학적 근거자료 마련 및 생물다양성 변화 실증자료 구축을 통한 제도 개선방안 마련 및 인식 개선을 위하여 벌채예정지를 중심으로 벌채유형별 곤충다양성 변화를 파악하기 위해 진행되었다. 금번 연구의 조사지는 강원 홍천 및 전북 무주 등 2개지역을 대상으로 실시하였다. 조사방법은 펀넬트랩, 핏폴트랩 및 스위핑법을 이용하여 조사하였다. 조사결과 홍천군 야시대리 일대 곤충상 조사 결과 총 10목 91과 367종 5,424개체의 곤충이 채집 조사되었으며, 무주군 설천면 미천리 일대 곤충상 조사 결과 총 13목 132과 442종 4,091개체의 곤충이 채집 조사되었다. 이들 연구결과는 향후 당해지역 내에서 벌채유형별 곤충상 변화양상을 구명하는데 기초자료로 활용될 것으로 기대된다.

검색어: 친환경벌채, 산림생태, 곤충상, 핏폴트랩, 쓸어잡기

P117

Insect pests and their damage occurring on olive tree in Jeju, Korea

Kyung San Choi[1], Sang-Wook Goh[1], Hyeonseok Oh[1], Hyojoong Kim[2], Sora Kim[3] and Jung-Joon Ahn[1*]
[1]Agricultural Research Center for Climate Change, NIHHS, RDA.
[2]Department of Biological Science, Kunsan University
[3]Department of Plant Protection & Quarantine, Jeonbuk National University

2019년부터 2021년까지 제주도 올리브(olive, *Olea europaea*)에서 발생하는 해충을 조사한 결과, 총 12 종의 해충이 발생하였다. 이중 나방류와 노린재류의 발생과 과실 피해가 매우 심했다. 나방류는 수수꽃다리명나방(*Palpita nigropunctalis*), 큰점애기잎말이나방(*Aterpia circumfluxana*), 차잎밀아나방(*Homona magnanima*) 순으로 많이 발생하여 주로 잎을 가해했지만, 수수꽃다리명나방은 과실들을 심하게 식해하였다. 그 외 나방류는 차주머니나방류(*Eumeta spp*)와 대만나방(*Paralebeda femorata*)도 발견되었다. 노린재류로는 썩덩나무노린재(*Halyomorpha halys*), 갈색날개노린재(*Plautia stali*), 풀색노린재(*Chinavia hilaris*)가 주로 발생하여 과실을 흡즙하였고, 피해과는 기형이 되었다. 깍지벌레류는 뽕나무깍지벌레(*Pseudaulacaspis pentagona*)와 갈색깍지벌레(*Chrysomphalus bifasciculatus*)가 발생하였는데, 뽕나무깍지벌레는 주로 나무의 밑둥 주변에, 갈색깍지벌레는 잎에서 관찰되었다. 그러나 여름 이후에는 두 종 모두 과실을 포함한 수체 전체로 확산하여 발생하였다. 진딧물류 해충은 *Prociphilus oleae*가 신초에 다량 발생하였는데, 국명으로 올리브면충이라 명명하였다. 총채벌레류는 꽃노랑총채벌레(*Frankliniella occidentalis*)가 개화기 꽃에서 발견되었다.

검색어: 올리브, 해충, 피해, 제주도

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P118

Degree of Cold Tolerance by Habitat in Southern area of Golden Apple Snail (*Pomacea canaliculata*)

Duck-Soo, Choi, Hyo-Jeong Kim, A-Hae Cho, Jin-Hee, Lee and Ji-In Kim
Environment-friendly Agricultural Research Institute, JARES, Jeonmam 58213, Korea

왕우렁이(*Pomacea canaliculata*)는 남미 원산의 열대성 동물로 월동생존 하한선은 0℃에서 35일, -3℃에서 3일, -6℃에서 1일로 알려져 있다. 그렇지만 국내 도입 후 30여년이 지나면서 내한성이 발달하여 겨울철 온도조건에 따라 다르지만 생존개체수가 점차 증가하는 경향이다. 따라서 남부지역 서식 왕우렁이를 대상으로 저온조건에 따른 생존율을 조사하여 내한성 발달정도를 구명하고자 하였다. 2021년 11월 전남 고흥, 해남, 나주지역에서 왕우렁이 성패를 채집하여 냉동기를 이용하여 저온에서 지속시간별 생존율을 조사하였다. 온도별 50% 치사시간(h)과 완전치사시간(h)이 0℃는 288h, 360h, -3℃는 18h, 70h, -6℃는 12h, 27h, -12℃는 3h, 9h였고, -18℃에서는 4시간 이후 완전치사하였다. 남부지역의 지역간 내한성 차이는 없었으며, 전국을 대상으로 지역별 내한성 발달정도 구명을 위한 추가연구가 필요할 것이다.

검색어: 왕우렁이, 내한성, 완전치사시간, 생존율

P119

Measurement and comparison of morphology of developmental stages of *Melanoplus differentialis* (Orthoptera: Acrididae)

Dayeong Kim, Nang-Hee Kim, Min-Ji Lee, Young-Gyu Ban, Beom-jun Jang, Heejo Lee and Dong Eon Kim*
Invasive Alien Species Team, National Institution of Ecology

무역 등 국가간 교류의 증가로 선박, 컨테이너에 편승되어 유입된 빗살무늬미주메뚜기(*Melanoplus differentialis*)는 2020년 7월 울산광역시 온산공단 일대에서 처음 발견되었다. 2020년 8월부터 2021년 11월까지 실내 및 실외에서 사육된 빗살무늬미주메뚜기의 발육단계별 형태를 측정하였다. 알집은 최소 3.8mm, 최대 5.5mm로 크기가 다양했으며, 알 하나의 크기는 평균적으로 4.9mm정도였다. 1령 약충 4.4mm, 2령 약충 6.3mm, 3령 약충 10.8mm, 4령 약충 13.5mm, 5령 약충 19.8mm, 6령 약충은 27.7mm정도로 나타났다. 성충 수컷은 36.5mm, 암컷은 41.6mm로 암컷이 수컷보다 약 5.1mm 가량 크기가 큰 것으로 나타났다. 암컷의 더듬이 길이는 14.5mm, 날개 길이는 30.6mm, 수컷의 더듬이 길이는 16.6mm, 날개 길이는 29.2mm 정도로 나타났다. 암컷의 몸길이와 날개길이는 더 긴 것으로 나타났으나, 더듬이 길이는 수컷이 더 2.1mm 정도 더 긴 것으로 나타났다. 몸길이, 날개길이, 더듬이 길이 외에 암수를 구분할 수 있는 가장 뚜렷한 특징은 세 번째 다리의 경골돌기 발달 유무다. 뿐만 아니라 미부생식기의 모양으로 암수를 구분할 수 있다.

검색어: 빗살무늬미주메뚜기, 외래 곤충, Grasshopper, 형태측정

P120

Selection of appropriate trap of *Ctenoplusia agnata* (Lepidoptera; Noctuidae) on soybean field by using three type traps

Da Gyeong Jeong[1], Bo Yoon Seo[2], Jin Kyo Jung[3] and Hye-Ok Gwon[1]
[1]Crop Protection Division, National Institute of Agricultural Science, RDA
[2]Crop Foundation Research Division, National Institute of Crop Science, RDA
[3]Crop Cultivation and Environment Division, National Institute of Crop Science, RDA

콩은무늬밤나방(*Ctenoplusia agnata*)은 아시아 열대지역에서 온대 북부지역까지 분포하는 밤나방과(Noctuidae) 해충이며, 콩과, 배추과 작물에 피해를 주는 다식성 해충이다. 국내에서 1973년 대발생이 있었다고 보고되었고, 매년 비래를 통해 국내 유입이 추정되고 있다. 최근 몇 년간 국내에서 콩은무늬밤나방 유충으로 인한 심각한 콩 잎 피해가 발견되어, 본 연구에서는 콩은무늬밤나방의 발생 조사를 위한 성페로몬트랩 선정을 위해 2021년 7월부터 10월까지 국립농업과학원 콩 포장에 트랩을 설치하여 트랩별로 포획한 콩은무늬밤나방의 개체수를 조사하였다. 조사기간동안 총 220마리의 콩은무늬밤나방이 포획되었으며, 콘트랩에서 97.73%, 펀넬트랩에서 1.36%, 델타트랩에서 0.91%가 포획되었다. 결과적으로 콩은무늬밤나방 포획용 트랩으로 콘트랩이 적합하다고 판단되었다. 본 연구 결과를 토대로 콘트랩을 이용하여 콩은무늬밤나방의 전국 발생소장을 파악할 예정이며, 조사 내용을 활용하여 콩은무늬밤나방의 방제전략을 세울 수 있는 기초 자료를 얻을 수 있을 것이다.

검색어: 콩은무늬밤나방, 성페로몬트랩, 콘트랩, 콩

P121

Prediction of occurrence of *Pseudococcus comstocki* (Hemiptera; Pseudococcidae) using temperature-dependent development and weather data in pear orchards

Sung-Wook Jeon, Hong Hyun Park, Minjae Kong, Jaekun Kim, Kwang-Ho Kim, Suni Song and Kyoung-Wha Kwon
Crop Protection Division, National Institute of Agricultural Sciences, RDA

농작물 재배에 있어 병해충 관리는 작물 수확량에 매우 큰 영향을 끼친다. 병해충 관리는 크게 사전관리와 사후관리로 구분되며, 수확량 손실을 방지하기 위해서는 사전관리가 가장 효과적이다. 본 연구는 배과원에 발생하여 과실 생산에 피해를 주고 있는 가루깍지벌레(*Pseudococcus comstocki*)에 대한 사전관리를 위해 온도발육실험과 기상자료를 토대로 성충 수컷의 발생을 예측한 결과 화성지역에서는 5/22일, 천안은 5/26일, 나주는 5/11일에 최초 성충이 출현할 것으로 예측되었고, 연간 발생은 화성과 천안은 각각 5회, 나주는 6회로 예측되었다.

검색어: 병해충, 사전관리, 배과원, 가루깍지벌레, 발생 예측

P122

Mass rearing method for *Thrips tabaci* (Thysanoptera: Thripidae) in Lab.

So-Hee Kim, Young Su Lee, Jong Yoon Choi, Hyun-Ju Lee, Sang-Woo Lee and Jung-Su Park
Gyeonggi Agricultural Research and Extension Services, Hwaseong 18388, Korea

Onion thrips, *Thrips tabaci* Lindeman(Thysanoptera: Thipidae) is the major pest of horticultural crops with wide range of host plants, short generation time, and insecticide resistance that make difficult to control. In this study, we confirmed oviposition preference on different five host plants and selected garlic as the most suitable host plant. This mass rearing method was systematized under room conditions(25±1°C, 50~60% RH, 16L:8D photoperiods). It is expected to be helpful to research about management of onion thrips in laboratory.

Key words: Onion thrips, *Thrips tabaci*, mass rearing, garlic

P123

Seasonal and environmental surveillance of mosquitoes (Diptera: Culicidae) and flavivirus detection in Gyeongbuk province, 2021

Ye Eun Park[1], Kyung Hwan Moon[1], Yeong Ho Kim[2], Jooheon Cha[3] and Young Ho Kim[1,2,3*]
[1]Department of Vector Entomology
[2]Department of Ecological Science
[3]Department of Applied Biology, Kyungpook National University

Female mosquitoes were monitored at three different environments (migratory bird refuge, urban area, and cowshed) in 2021. Among total 4,041 female mosquitoes collected in 2021, 12 species belonging to 6 genera were identified. A total of 2,975, 722, and 344 mosquitoes were collected in the migratory bird refuge, urban area, and cowshed, respectively. *Aedes vexans* was the dominant species in the migratory bird refuge, while *Culex pipiens* complex and *Anopheles* spp. were dominantly collected in the urban area and the cowshed, respectively. The period of mosquito occurrence in the urban area was longer than that in the migratory bird refuge. Flavivirus was detected from 5 pools among 252 tested pools. Three pools were positive for Chaoyang virus, and two pools were positive for Japanese encephalitis virus type V.

Key words: Mosquito, Gyeongbuk province, Flavivirus, Japanese encephalitis

P124

Changes in the Vespa hornets colonies (Hymenoptera: Vespidae) by the season and habitat in 2018-2021

Ju-Gyeong Kim, Yong-Soo Choi, Dongwon Kim, Eun-Jin Kang, Bo-Sun Park, Kyungmun Kim, Daegeun Oh and Su-Bae Kim
Apiculture Division, Department of Agricultural Biology, National Institute of Agricultural Sciences, RDA

본 연구는 전북 전주 소재의 국립농업과학원에서 시기와 서식처에 따른 말벌류의 군집 변화를 관찰하기 위해 4년간 서식처별로 말벌류 발생 양상을 관찰하고 군집 분석을 실시하였다. 모니터링은 2018년부터 2021년까지 매년 4월 초순부터 11월 말까지 일주 간격으로 진행되었으며 말벌 유인트랩을 이용하여 조사하였다. 유인트랩에 포획된 말벌류의 총 개체수는 2018년에 495마리, 2019년 1,281마리, 2020년 1,264마리, 그리고 2021년 5,589마리였다. 등검은말벌의 개체수가 급증한 2021년에는 서식처와 상관없이 등검은말벌이 우점(양봉장 89%, 양봉장 인근 산림 73%, 산림 78%)하였으며, 양봉장과 산림에서는 좀말벌이 아우점(9, 10%)하였고, 양봉장 인근 산림에서는 장수말벌이 아우점(10%)했던 것으로 분석되었다. 한편, 좀말벌은 4년간 지속적으로 양봉장 출현률이 증가(p<0.05)했던 것으로 확인되었으며, 반대로 장수말벌은 양봉장 출현이 감소하면서 양봉장 인근 산림에서 출현률이 점차 증가하는 경향으로 파악되었다.

검색어: 시기별, 서식처별, 말벌류, 발생양상, 군집분석

P125

Life history characteristics of *Nabis stenoferus* (Hemiptera: Nabidae) under the three different types of food

Young-gyun Park, Minhyeok Kwon, Souvic Sarker and Un Taek Lim
Department of Plant Medicals, Andong National University, Republic of Korea

Nabis stenoferus is a zoophytophagous predator that lives in grasslands around agricultural land. It can feed on aphids, mealybugs, and moths and is a new candidate for biological control agent. To find the suitable condition for mass-rearing and to better understand this predator, we compared the life history characteristics of *N. stenoferus* under the three different food types: (1) aphid (*Myzus persicae*), (2) moth egg (*Cadra cautella*), and (3) aphid + moth egg. Interestingly, when only aphid was supplied as food, *N. stenoferus* could develop successfully up to the adult stage but with almost zero fecundity. The intrinsic rate of increase was significantly higher in a mixed diet of aphid and moth egg than in either moth egg or aphid only condition. In conclusion, aphid can be a supplementary food for mass rearing system for of *N. stenoferus* where only moth eggs are used as food source

Key words: Biological control, Life table, Mass-rearing, Natural enemy

P126

A study on the habitat status of Argentine Ants, *Linepithema humile* (Mayr) (Hymenoptera: Formicidae: Dolichoderinae) in Korea

Min-Ji Lee, Yeong-Gyu Ban, Dayeong Kim, Nang-Hee Kim, Hee jo Lee, Beom-jun Jang and Dong Eon Kim*
*Invasive Alien Species Team, National Institute of Ecology, Seocheon, Korea

아르헨티나개미(*Linepithema humile*)는 2019년 8월 부산에서 붉은불개미 등 위해 외래개미류 예찰을 통해 처음 확인되었다. 부산역을 중심으로 인도변, 건물 내, 돌틈, 화단, 철로, 컨테이너야적장 등 약 1.5km 범위에서 서식이 확인되었다. 국내 개미류는 주름개미, 스미드개미, 도토리개미, 중국집개미 등 총 4과 17속 21종이 확인되었으나, 아르헨티나개미가 우점하는 지역에서는 국내 개미류가 1/3 가량 감소되었다. 서식이 확인된 지역의 식물상은 총 37과 64종이었고, 그 중에서 감국, 동백나무, 맥문동, 팔손이 등 총 7과 9종에서 먹이활동이 확인되었다. 이처럼 아르헨티나개미는 국내에 적응하여 토착생태계의 불균형 및 인간의 생활반경에 침입하여 피해를 입히고 있으므로, 지속적인 모니터링과 생태특성을 고려한 방제방법이 필요할 것으로 보인다.

검색어: *Linepithema humile*, 아르헨티나개미, 부산광역시, 식물상, 먹이식물

P127

Effects of cold temperature on survivorship of *Spodoptera frugiperda* (Smith) pupae

Hyung Cheol Moon, Su Ji Jang, Min Kyung Choi, Ju Hee Kim, So Ra Choi and Hyong Gwon Chon
Agricultural Environment Division, Jeonbuk Agricultural Research and Extention Services

열대 및 아열대지역이 원산지인 열대거세미나방이 2019년부터 국내에 비래하여 옥수수 등에 피해를 주고 있어 이 해충의 국내 월동가능성을 검토하였다. 용화 2일째인 번데기를 1±0.5℃와 4±0.5℃에 일정기간 처리한 후 25±1℃에서 생존율을 조사하였다. 4℃에 번데기를 1, 3, 5일 동안 처리한 결과 생존율은 90% 이상이었으나 20일 이상 처리할 경우 생존한 개체는 없었다. 1℃에서는 1일 처리한 결과 93%의 생존율을 보였으나 처리 기간이 길어질수록 생존율은 감소하여 7일 이상 처리한 경우 생존율이 급격하게 감소하였다. 또한 10월에 토양 깊이 10cm근처에 번데기를 묻어두고 월동 후 조사한 결과 생존 개체는 없었다. 따라서 국내에서 열대거세미나방의 월동가능성은 매우 낮은 것으로 판단되었다.

검색어: 열대거세미나방, 번데기, 생존율, 저온처리

P128

Occurrence of *Riptortus clavatus* in soybean paddy fields in Jeonbuk Province

Hyung Cheol Moon, Su Ji Jang, Min Kyung Choi, Ju Hee Kim, So Ra Choi and Hyong Gwon Chon
Agricultural Environment Division, Jeonbuk Agricultural Research and Extention Services

전북지역 논 콩 재배면적은 5,980 ha로 전국 논 콩 재배면적의 59%를 점유하고 있다. 논 콩 재배가 증가함에 따라 콩 수량 및 품질에 가장 큰 피해를 주는 톱다리개미허리노린재의 전북지역 발생량을 조사하기 위하여 김제 등 9개 지역 논 콩 주요 재배 포장에 페로몬트랩을 설치하고 7월부터 10월까지 채집된 개체수를 조사하였다. 지역별 월 1회, 7일 동안 채집한 결과 조사지역 모두 착협기인 8월 중순에 가장 많이 채집되었고, 전주, 군산, 순창, 고창 지역은 9월 중순에도 채집량이 많았다. 익산지역 밭 포장에서 7일 간격으로 채집량을 조사한 결과 7월 하순이후 발생이 증가하여 8월 중순과 9월 상순에 발생최성기를 보여 지역별 논 콩에서의 조사 결과와 같은 경향이었다.

검색어: 톱다리개미허리노린재, 논 콩, 페로몬트랩, 채집량

P129

Diversity pattern of macromoths in agricultural ecosystem with the effect of landscape composition and configuration

Jae-Young Lee[1] and Sei-Woong Choi[2]
[1]Department of Biology, Mokpo National University
[2]Department of Environmental Education, Mokpo National University

농업활동의 증가는 경작지 확대와 경관 구성의 획일화로 서식지 감소와 파편화를 가속화시킨다. 서식지 파편화는 종 풍부도의 감소와 종 구성 패턴의 단순화, 그리고 생태계 구조 특성 변화 등 생물다양성과 생태계에 큰 영향을 미친다. 이처럼 생물은 주변 경관의 영향을 받기 때문에 경관의 구조와 생물과의 관계를 알아보기 위한 다양한 연구가 진행되고 있으며, 경관을 객관적으로 이해하고 사용하기 위한 경관지수를 개발하여 생태연구에 사용하고 있다. 본 연구의 목적은 대한민국 서남부 10지역에서 숲 형태에 따른 경관 구성이 대형나방의 종과 과별 다양성에 영향을 미치는지 확인하는데 있다. 2018-2020년 5월부터 10월에 Black light trap을 이용해 대형나방을 조사하였다. 경관의 구성과 형태분석은 환경부 토지피복도를 기준지도로 사용하였으며, 조사지점을 중심으로 면적과 경관지수를 산출하였다. 종 다양성은 반경 100m 이상을 buffer로 설정한 경관에서 효과가 나타나는 것으로 확인되었다. 과별 다양성 양상은 자나방과는 파편화되고 교란된 지역에서 종 다양성의 감소하는 경향이 나타났지만 밤나방과, 태극나방은 반대의 경향이 나타났다. 과별 분산능력과 이용하는 먹이원의 차이로 이러한 경향이 나타난 것으로 예측된다. 조사시점에 서식하는 식물과 기주식물로 이용하는 관계를 종 또는 과 수준에서 연관성이 나타나는지에 대한 추후 연구가 필요할 것으로 판단된다.

검색어: 대형나방, 군집구성, 농업경관, 생물다양성

P130

Field validation for the phenology models of *Agrotis ipsilon* (Lepidoptera: Noctuidae) and hypothesis for the initial establishing population in early season in Korea

Sori Choi, Jinwoo Heo, Subin Kim, Myeongeun Jwa, Yonggyun Shin and Dong-soon Kim*
Majors in Plant Resource Sciences & Environment, College of Applied Life Science, SARI, Jeju National University, Jeju 63243, Republic of Korea

검거세미나방은 배추, 감자, 옥수수 등 중요한 작물을 가해하는 해충으로 특히 지하부를 가해하여 피해가 크며 방제가 어려운 대표적 해충이다. 국내에서는 유충상태로 월동하는 것으로 주요 영농책자에 표기되어 있으나, 아직 확실한 자료가 존재하지 않는다. 온도의존 적산온도 모형을 이용하여 유충 및 성충 출현 관측일을 기준으로 발육단계를 추적 또는 역추적하여 실제로 발생 가능한지를 평가하였다. 분석결과 우리나라에서 유충이나 번데기로 월동하지 않는 집단에서 초기 개체군이 수립될 수 있다는 것이 확인되었다. 즉 3~4월 이른 성충 출현은 국내 월동 개체군으로 설명할 수 없었다. 또한 유충으로 월동하는 집단의 가능성도 있었으며 이 집단은 6월 성충으로 우화가 가능하였다. 종합적으로 볼 때 우리나라에서 검거세미나방 개체군은 장거리 이동을 통한 이주 개체군과 월동 개체군이 혼재하여 형성되는 것으로 추정되었다.

검색어: 검거세미나방, 발생예찰, 적산온도, 페놀로지 모형, 장거리 이주

P131

The report for the damage of *Saridoscelis sphenias* (Lepidoptera: Yponomeutidae) on blueberry trees

Oh Jin-bo[1], Park Young-mi[1], Oh Si-heon[1] and Dong-soon Kim[2*]
[1]Animal and Plant Quarantine Agency
[2]Majors in Plant Resource Sciences & Environment, College of Applied Life Science, SARI, Jeju National University, Jeju 63243, Republic of Korea

나방과(Yponomeutidae)에 속한 작은상제집나방(*Saridoscelis sphenias* Meyrick)은 2016~2017년 전남 진도와 완도에서 채집된 개체를 동정하여 2020 국내 미기록 종으로 보고되었으며, 마취목(*Pieris japonica*)과 진달래과에 속한 모새나무(*Vaccinium bracteatum* Thunb.)와 *Leucothoe grayana* Maxim. var *oblongifolia* (Miq.)가 기주식물로 알려져 있었다. 이 종은 2014년 8월 제주특별자치도 블루베리 재배지에서 처음 발견된 후 미정착된 것으로 취급되었으나, 2018년에 이어 2019년에도 제주시와 서귀포시 여러 블루베리 농장에서 발생이 확인되었다. 그 후 2020년부터는 노지 과원에서도 발견되고 있다. 유충이 처음 신초 줄기 속으로 침입하여 가해하다가 중간크기로 자란 후 탈출하여 몇 개의 신초를 거미줄로 철하고 집단적으로 가해하는 등 특이한 피해증상이 나타난다. 향후 피해가 우려되는 해충으로 피해증상과 생활사를 간단히 보고한다.

검색어: 블루베리 해충, 작은상제집나방, 피해증상, 새로운 해충, 신초고사

P132

Survey on the occurrence of sporadic and subtropical insect pests for vulnerability assessment of their negative impacts in agriculture caused by climate change

Jaekun Kim[1], Kwang-Ho Kim[1], Hong Hyun Park[1], Sung-wook Jeon[1], Minjae Kong[1] and Yong Hong[2]
[1]Crop Protection Division, National Institute of Agricultural Sciences, RDA.
[2]Department of Agriculture Biology, College of Agriculture & Life Science, Jeonbuk University

최근 기후변화가 진전됨에 따라 먹노린재(*Scotinophara lurida*) 등의 돌발해충과 톱다리개미허리노린재(*Riptortus clavatus*) 등의 남방계 해충 국내 발생 빈도 및 대규모 출현율이 증가하고 있는 추세이지만, 발생의 불규칙성으로 인해 이들 해충에 대한 대비책은 상당히 미흡한 실정이다. 그로 인해 표준화된 기후변화 실태조사 방법에 따른 각 지역별 장기간의 조사를 통해 실제적 기후변화 경향성 및 영향 평가가 필요하다. 따라서 본 연구에서는 향후 발생지역과 미발생지역간의 취약성 평가, 미발생 지역의 발생 가능성, 해충 발생시 농작물에 미칠 영향평가를 위하여 먹노린재와 톱다리개미허리노린재에 대해 전국 단위 발생 실태조사를 실시하였다. 먹노린재와 톱다리개미허리노린재 전국 발생 실태조사를 실시한 결과 먹노린재는 경남(2.56), 전북(1.39), 충북(1.27)순으로 발생이 많았고, 톱다리개미허리노린재는 전남(156.2), 경남(79.9), 전북(76.6)순이었다. 이 결과를 바탕으로 대발생 가능 해충관리 및 확산 저지방안을 마련하고 농작물 안전생산 기술개발의 기초자료로 활용할 예정이다.

검색어: 기후변화, 실태조사, 돌발해충, 남방계 해충, 먹노린재, 톱다리개미허리노린재

P133

Operation of invasive alien species report center

Beom-jun Jang, Dayeong Kim , Min-Ji Lee , Yeong-Gyu Ban, Hee jo Lee, Nang-Hee Kim and Dong Eon Kim*
Invasive Alien Species Team, National Institute Of Ecology

국가간 무역의 증가와 기후변화 등으로 외래생물의 국내 유입 가능성이 높아짐에 따라 국내 생태계로의 확산이 우려되는 실정이다. 국립생태원에서는 붉은불개미 등 위해 외래생물의 유입에 따른 국민 불안감을 해소하고 신고 접수 건에 대한 신속한 대응을 위하여 외래생물 신고 콜센터(041-950-5407, 010-5744-5407), 메일(kias@nie.re.kr), 웹페이지(https://kias.nie.re.kr)를 2018년 10월부터 현재까지 상시 운영하고 있다. 2018~2021년까지 총 신고 건수는 694건이며 각 신고 건에 대해 객관적인 정보를 신속히 제공하고 신고 즉각 대응 및 시민행동 지침을 개별적으로 안내하고 있다. 연도별 신고 건수는 2018년 85건(곤충 80%), 2019년 311건(곤충 80%), 2020년 172건(곤충 83%), 2021년 126건(곤충 63%)이 접수 되었다. 2018~2021년 붉은불개미 의심 신고 건수는 653건이며, 이 중 개미류가 아닌 권련침벌(*Cephalonomia gallicola,* 22%)과 빨간진드기(*Balaustium mutotum,* 10%)가 가장 많이 신고되었고, 개미류는 노랑꼬리치레개미(*Crematogaster osakensis,* 7%), 애집개미(*Manamorium pharaonis*, 5%) 분개미(*Formica sanguinea*, 3%)가 주로 신고되었다.

검색어: 외래생물, 신고 콜센터, 붉은불개미, 외래곤충

P134

Investigation of feeding amount and growth period of *Spodoptera frugiperda* according by temperature

Seongkyun Lee, Younguk Park, Seokho Lee, Sunhee Kang and Juhyung Kim
Chungbuk Agricutural Research and Extension Services

열대거세미나방은 2019년 제주에서 국내 첫 발견되어 매년 지속적으로 발생을 하고 있는 해충으로 중국(대만)으로부터 편서풍을 타고 비래한다. 열대거세미나방은 80여종의 식물을 가해하는 광식성 해충으로 특히 벼과 식물을 선호하는데 국내의 경우 옥수수에서 그 피해가 가장 심하게 나타난다. 따라서 비래 이후 적정방제 적기를 설정하고자 온도별(24, 28, 32, 36℃) 발육기간 및 옥수수 섭식량을 조사하였다. 그 결과, 섭식량의 경우 24℃ 2.9g, 28℃ 4.6g, 32℃ 5.6g, 36℃ 3.0g으로 32℃의 섭식량이 가장 많았으며, 발육기간의 경우 24℃ 23.2일, 28℃ 19.0일, 32℃ 16.9일, 36℃ 16.2일로 32℃에서 발육기간이 가장 짧은 것으로 조사 되었다. 또한 사육 중 24~32℃의 생존율은 100%로 조사된 반면 36℃의 생존율은 50%로 36℃를 넘어서면 생존율이 낮아지는 것으로 조사되었다. 따라서 이와 같은 결과를 종합해 볼 때 열대거세미나방의 생육적온은 32℃로 판단된다.

검색어: 열대거세미나방, 온도별 섭식량, 발육기간, 생존율

P135

Oviposition preference of the bean bug, *Riptortus pedestris* (Hemiptera: Alydidae), under laboratory conditions

Juhwa Oh, Minhyung Jung and Doo-Hyung Lee
Department of Life Sciences, Gachon University, Gyeonggi-do, South Korea

Riptortus pedestris is a major agricultural pest on leguminous plants in Eastern Asia including South Korea and Japan. In this study, we evaluated oviposition preference of *R. pedestris* and compared between symbiotic and apo-symbiotic insects. Preference was investigated in acrylic boxes provided with a kidney bean plant (V4 stage) as host-plant, and soil and rocks as non-host materials. Then, daily fecundity and location of eggs were recorded over 7 days. In the experiment, symbiotic *R. pedestris* displayed significantly higher fecundity compared to apo-symbiotic insects ($P < 0.05$). However, no significant difference was observed in oviposition preference between symbiotic and apo-symbiotic insects, where the highest number of eggs was observed from walls of acrylic box followed by rock and ventral part of leaves. Therefore, among the potential oviposition structures, *R. pedestris* preferred to oviposit on non-host plant materials, regardless of symbiont inoculation, in laboratory conditions.

Key words: insect-microbe symbiosis, reproductive behavior, crop pest, leguminous

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P136

Spatially explicit model simulating dispersal of *Leptoglossus occidentalis* based on population growth and forest-product transportation

Xiaodong Zhang[1,2], Yang Zhou[1,2], Dae-Seong Lee[3], Young-Seuk Park[3] and Tae-Soo Chon[2,4]
[1]Dept. of Electrical and Electronics Engineering, Pusan National Univ.
[2]Ecology and Future Research Institute
[3]Department of Biology, Kyung Hee Univ.
[4]Major of Life Science, Incheon National Univ.

Since invasion of the leaf-footed bug, *Leptoglossus occidentalis*, in 1988, the forest pest has expanded rapidly across the southern peninsula of Korea in 2020s. A spatial network model based on national data for forest-production transport was developed to present passive movement of the forest pest according to the gravity rule. Subsequently spatially explicit models were formed to present population growth and active movement. Two models were linked in each iteration: passive transport obtained by the spatial network models was combined to population growth and active movement by the spatially explicit model at the corresponding locations. Simulation results were compared with field data. Model parameters related to transportation of forest-product and population growth were examined regarding spatial population advancement patterns.

Key words: forest pest, dispersal, passive movement, monitoring, pest management

P137

Simulating dispersal of the leaf-footed bug, *Leptoglossus occidentalis*, using individual based model in presenting combined effects of natural and human factors

Yang Zhou[1,2], Xiaodong Zhang[1,2], Dae-Seong Lee[3], Young-Seuk Park[3] and Tae-Soo Chon[2,4]
[1]Dept. of Electrical and Electronics Engineering, Pusan National Univ.
[2]Ecology and Future Research Institute
[3]Department of Biology, Kyung Hee Univ.
[4]Major of Life Science, Incheon National Univ.

Local areas were defined to simulate saptio-temporal dispersal of a forest pest, *Leptoglossus occidentalis*, population with an individual based model (IBM). Initially rules for natural life events, birtht, death, metamorphosis and active movement were provided to the IBM. Subsequently the factors related to human influence were incorporated to the IBM, including transport effect, availability of seedlings and human residence. The dispersal patterns were examined according to changes in parameters presenting natural and anthropogenic effects. Simulation results were compared with advancement patterns obtained from field data. Relational effects between natural and human factors were discussed in monitoring and management of forest pest dispersal.

Key words: forest pest, invasion, spatial dispersal, monitoring, life events

P138

Awareness survey on farmers to refrain from illegal incineration of rice paddy fields and upland fields

Minjae Kong, Sungwook Jeon, Kyoung-Hwa Kwon, Soon-I Song, Hong-Hyun Park and Kwang-Ho Kim
Crop Protection Division, National Institute of Agricultural Sciences, RDA

논·밭두렁 소각은 날씨가 건조한 2월부터 4월 사이 이루어져 산불 발생 뿐만 아니라 미세먼지 발생, 대기오염 등 다양한 부정적인 영향을 최소화하기 위해 관련 부처에서는 불법소각에 대한 위험성 및 홍보가 이루어지고 있는 실정이다. 이에 따라 본 연구는 논두렁 불법소각 금지를 위해 실제 농업인에게 일반현황, 재배이력, 태우기 실태조사 등의 설문조사를 통한 인식조사 결과(130부), 벼, 보리, 밀 등의 식량작물 재배(60.0%)가 많았으며, 관행재배(82.3%)가 많은 것으로 분석되었다. 농업인 중 소각 횟수는 평균 약 2.5회, 소각은 1월~3월 이루어지는 것으로 분석되었으며, 소각의 목적은 병해충·잡초방제(50.0%), 쓰레기(18.8%) , 영농부산물(12.5%) 등으로 나타났다. 논두렁 외 소각 경험은 약 52.3%로 나타났으며, 소각 이유로는 영농부산물 및 쓰레기의 처치곤란(57.4%)이 가장 많게 분석되었다. 이러한 문제를 해결하기 위한 지차제별 지원 및 다양한 불법소각 자제를 위한 정부 정책이 필요한 것으로 판단된다.

검색어: 논두렁, 태우기, 병해충방제, 불법소각

P139

Ecological characteristic of differential grasshopper, *Melanoplus differentialis* in South Korea

Nang-Hee Kim, Min-Ji Lee, Dayeong Kim, Yeong-Gyu Ban, Beom-jun Jang, Hee jo Lee and Dong Eon Kim*
Invasive Alien Species Team, National Institute of Ecology

북미 원산인 빗살무늬미주메뚜기(*Melanoplus differentialis*)는 옥수수, 콩, 밀 등 다양한 작물에 피해를 입히는 해충이다. 국내에서는 2020년 울산 온산항 일대에서 최초로 서식이 확인되었으며, 2020년 12월 환경부 법정관리종인 생태계교란 생물로 지정되었다. 이에 국내에 서식하는 빗살무늬미주메뚜기의 생태적 특성을 파악하고자 연구를 수행하였다. 알로 월동하는 빗살무늬미주메뚜기는 4월경 약충이 출현하며, 부화 후 6번의 탈피를 거쳐 성충이 된다. 성충은 8월경 짝짓기를 하며, 11월까지 활동이 확인되었다. 성충은 한 번에 150여개의 알을 낳으며 알의 부화율은 약 88%로 높았다. 빗살무늬미주메뚜기의 서식지 유형은 초지, 나지, 도로변 등 다양하였고 서식지에서 확인된 기주식물은 16목 18과 32종이었으며 국화과(Asteraceae)의 쑥, 망초류와 콩과(Fabaceae)의 칡, 싸리나무류 등을 선호하는 것으로 나타났다. 빗살무늬미주메뚜기는 대형 메뚜기 중 하나로 국내 토착종 중 경쟁이 될 만한 종이 없고, 먹이 습성이 다양하여 농경지, 산림지 등에 피해를 일으킬 우려가 높은 종으로 생태 특성 파악과 지속적인 모니터링을 통해 확산 양상을 예측하고 효율적인 관리 방안을 모색할 필요가 있다.

검색어: 빗살무늬미주메뚜기, *Melanoplus differentialis*, differential grasshopper, 외래곤충, 생태계교란 생물

P140

Development of dispersion model for *Leptoglossus occidentalis* (Hemiptera; Coreidae) based on agent-based model

Dae-Seong Lee[1], Tak-ki Lee[2], Yang-Seop Bae[2] and Young-Seuk Park[1]
[1]Department of Biology, Kyung Hee University, Republic of Korea
[2]Division of Life Sciences, Incheon National University, Republic of Korea

소나무허리노린재(*Leptoglossus occidentalis* Heidemann, 1910)는 소나무류 구과를 가해하는 해충으로, 우리나라에서는 2010년 경남 창원시에서 처음 관찰된 이후, 전국적으로 확산되고 있다. 소나무허리노린재의 확산 지역 및 확산 경로 예측을 위해, 본 연구에서는 행위자 기반 모형(agent-based model)을 이용하여 소나무허리노린재에 대한 전국 확산 모형을 제작하였다. 모형에 사용한 매개 변수는 관련 문헌 및 실험, 야외 모니터링 등을 통해 획득하였다. 특히 사육 실험을 통해 유효적산온도에 대한 사망 확률 분포를 제작하였고, 전국 모니터링 자료를 이용해 소나무허리노린재 성충의 이동 및 확산 거리 분포를 추정하였다. 제작한 확산 모형을 모의한 결과, 소나무허리노린재의 일반적인 개체군 동태와 장거리 확산 양상을 확인할 수 있었다.

검색어: 외래해충, 소나무허리노린재, 행위자 기반 모형, 확산 모형

P141

Effect of chilling temperature on mortality of overwintering eggs of Asian gypsy moth, *Lymantria dispar* in Korea

Keonhee E. Kim, Min-Jung Kim, Yonghwan Park, Chan Sik Jung and Youngwoo Nam
Forest Entomology and Pathology Division, National Institute of Forest Science, Seoul 02455, Korea

Asian gypsy moth, Lymantria dispar, has sporadically outbreak in Korea. Because L. dispar overwinters as egg, chilling temperature would be a key factor for determining egg mortality and population size in the spring season in relation to the current climate change. In this study, we collected the egg mass of L. dispar from ten regions in Korea before winter. The egg mass were allocated to five chilling temperature conditions (-12, -6, 0, 6, or 12°C) for 100 days, and then moved to the chamber of 25°C for inducing post-diapause development. The mortality of L. dispar egg was significantly affected by the chilling temperature in all sampled regions. The overall mortality rate of L. dispar was highest at –12°C, and the rate decreased as the temperature rose to 0°C. Above 0°C, the mortality rate increased as the temperature increased. The sampled population could be divided into two population clusters based on the measured mortality rate.

Key words: Asian gypsy moth, *Lymantria dispar*, Chilling temperature, Egg mortality, Overwintering

P142

Seasonal occurrence of the western conifer seed bug, *Leptoglossus occidentalis* Heidemann from cone of korean white pine and cone damage by period

Gun-Hyung Kwon[1], Sun-Hee Kim[1] and Young-Woo Nam[2]
[1]Gyeonggido Forestry Enviroment Research Center
[2]Division of Forest Insect Pests and Diseases, National Institute of Forest Science

소나무허리노린재는(Leptoglossus occidentalis)는 북미원산으로 2010년 경남 창원에서 국내 침입이 처음 확인되었다. 최근 까지는 소나무 구과에서 피해에서 나타났으나 이로 인한 피해는 수목생육에 직접적인 영향이 적은 편이다. 그러나 2020년 경기도 가평군 잣나무 구과에서 피해가 확인되었는데, 잣나무 구과는 산림에서 경제적으로 매우 중요한 소득작물로 이로 인한 피해가 문제가 되기 시작하였다. 잣나무 구과에서 소나무허리노린재 발생소장 조사를 위해 경기도 가평군 6개 지역의 잣나무 상부에 타임랩스 카메라(TLC2020,Brinno)설치하고 영상분석을 통해 잣 구과에서 소나무허리노린재 발생소장을 조사한 결과, 잣 구과에서 2021년 6월 7일에 최초 관찰되기 시작하여 11월 7일까지 관찰되었다. 시기별 구과 피해율 조사를 위해 잣나무 구과에 4월 초순에 망대를 사전에 설치하고 5월 중순부터 각 시기별로 소나무허리노린재를 15일 간격으로 접종시켜 가해토록 한 후 제거하여 가해시기에 따른 구과 피해율을 조사한 결과 잣 구과가 주로 성숙하는 6~7월 경이 잣 구과피해율이 높았으며 7월 하순부터는 구과 피해율이 낮아지는 경향을 보였다.

검색어: 소나무허리노린재, 잣 구과, 발생소장, 구과 피해율, 타임랩스카메라

P143

Temperature-dependent development model of *Lymantria dispar*

A-Hae Cho, Duck-Soo Choi, Hyo-Jeong Kim, Jin-Hee Lee and Ji-In Kim
Environment-Friendly Agricultural Research Center, Jeollanamdo Agricultural Research and Extension Services

매미나방(*Lymantria dispar*)의 방제기술 개발을 위하여 온도의존 발육모형을 산출하였다. 2021년 매미나방 난괴 생존율을 조사한 결과 총 3,612개 중 3,147개 생존하여 생존율은 87%였고 좀벌류 기생율은 1.4%였다. 온도의존 발육모형을 구하기 위하여 18, 21, 24, 27, 30, 33℃(14L:10D) 조건의 항온기에서 온도별, 발육단계별 발육기간을 조사하였다. 18, 21, 24, 27, 30, 33℃의 온도 조건에서 1령에서 성충이 될 때까지의 기간은 각각 110.2, 79.2, 61.3, 57.9, 54.1, 52.4일이었으며, 온도별 생존율은 85, 95, 90, 100, 95, 60%였다. Excell 프로그램을 이용하여 온도와 발육속도와의 관계를 2차 다항식으로 분석하여 회귀곡선을 얻었고 이를 근거로 발육단계별 발육영점온도와 유효적산온도를 산출하였다. 1령에서 성충까지 매미나방 발육영점온도는 12.7℃, 유효적산온도는 795.6DD였다.

검색어: 매미나방, 발생생태, 발육영점온도, 유효적산온도, 온도발육모형

P144

Comparison of symptom development of pine wilt disease on *Pinus thunbergii*, *P. densiflora* and on *P. koraiensis* under temperature gradient greenhouse and CO_2 temperature gradient greenhouse

Heejung Kim, Sujin Lee, Youngwoo Nam, Chansik Jung and Hyerim Han
Division of Forest Insect Pests & Diseases, National Institute of Forest Science, Seoul 02455, Korea

To investigate the pattern of symptom development of pine wilt disease-infected trees with climate change factors and CO_2 we simulated the climate changes under temperature gradient greenhouse conditions located at the Forest Technology Management Research Institute in Pocheon-si Gyeonggi-do province and tested the change of symptom development. As a result of comparing the difference with the external temperature for each zone, the general temperature gradient greenhouse (zone 1: +0.5℃, zone 2: +0.8℃, zone 3: +2℃), CO_2 temperature gradient greenhouse (zone 1: +1.7℃, zone 2: +2℃, zone 3: +1.7℃). *Pinus thunbergii, Pinus densiflora,* and *Pinus koraiensis* seedlings were used as hosts for each zone, 10,000 pine wilt nematodes were inoculated each, and symptoms were observed for 18 weeks. *P. thunbergii* was able to observe that in both greenhouses, the symptoms increased as the temperature increased *P. densiflora* stopped at about 70% when both greenhouses reached the 18th week, so the whole did not die, *P. koraiensis* showed the highest degree of apoptosis at 100% in zone 3 with high CO_2 concentration.

Key words: climate change, pine wilt disease, pine wood nematode, symptom, temperature

P145

The Occurrence and proper control of Beet armyworm(*Spodoptera exigua*) in Shine musket vineyards in chungcheongbuk-do

Myungkyu Song[1], Yeuseok Kwon[1], Jeongmoon Cha[1], Changwon Jeong[1], Eunjin So[1], Gyeongja Lee[1] and Gilha Kim[2]
[1]Chungcheongbuk-do Agricultural Research & Extension Services
[2]College of Agriculture, Life & Environment Sciences, Chungbuk National University

샤인머스켓은 가격이 높게 형성되어 재배면적이 증가하는 추세로 전국 재배면적('20)은 2,913ha 정도로 3번째로 많이 재배하는 품종이다. 샤인머스켓 잎은 캠벨얼리나 거봉 잎과 달리 얇아 파밤나방 유충이 가해를 하여 1~2년생 샤인머스켓 포도나무 생장을 저해하는 것으로 관찰되었다. 무엇보다도 정식 후 해충관리를 안하고 있다가 노령유충이 보이는 시기에 농가가 뒤늦게 인식하고 방제를 해 방제효과가 떨어지는 어려움을 겪고 있다. 1년생 샤인머스켓 묘목을 정식한 옥천지역 무가온 비닐하우스에서 4월 중순 성충이 관찰된 후 5월초부터 유충이 잎을 가해해 6월 중순 유충 밀도 및 잎 피해가 가장 높았다. 그 후 잎이 단단해지는 7월 중순 이후에는 포도잎에서 유충이 줄어들었다. 1, 2년생 샤인머스켓 포도원에서 파밤나방 피해를 줄이기 위해 포장 내 4월 초부터 페로몬트랩으로 성충을 유살하고, 5월 초 1~2령 유충시기에 등록약제와 유기농자재를 살포한 후 신초 위주로 추가 방제를 해 피해를 줄일 수 있다.

검색어: 포도, 파밤나방, 샤인머스켓, 발생, 방제

P146

Establishment of the prediction system database and occurrence survey on the major insect of Persimmon(*Diospyros kaki*) in Gyeonsangbuk-do Province

Jeong-Seok Ha, In-Kyu Song, Jong-Pil Lee, Mun-Kyeong Cho and Hye-Young Suh
Gyeongsangbuk-Do ARES Sangju Persimmon Research Institute

경북의 떫은감 재배면적은 5,655ha(전국의 40%), 생산량 87,525톤(전국의 54%)으로 경상북도는 중요한 떫은감 생산지이다. 신종 병해충이 증가되고 있지만 국가차원에서 종합적인 정보가 관리되지 못하고 있어 돌발 병해충 출현시 대응체계가 미흡한 실정이다. 따라서 돌발해충을 미리 예측할 수 있고, 밀도가 늘어나고 넓은 지역으로 확산되기 전에 조기에 발견하고 대응할 수 있는 예찰망이 필요하다. 돌발해충을 조기 발견하고 대응하기 위하여 해충 발생예측 정보 및 데이터베이스 구축과 관련하여, 경북지역내 시기별 주요 해충 발생량을 조사하였다. 조사방법으로 총채벌레류, 노린재류 등 주요 해충을 감 생육기인 4월부터 10월까지 육안조사, 페르몬트랩, 끈끈이트랩 등을 이용하여 해충 발생밀도 및 피해률을 조사하였다. 조사결과 애무늬고리장님노린재 피해엽률 9.31%, 총채벌레류 피해과률 28.5%, 담배거세미나방 피해엽률 4.5%, 미국흰불나방 피해엽률 2.9%로 확인되었다. 미국선녀벌레 1세대는 적산온도 484.6℃, 발생예측일은 6월 17일, 포장 초발생일 6월 21일로 조사되었으며, 갈색날개매미충은 적산온도 429.3℃, 발생예측일은 5월 7일, 포장 초발생일은 5월 15일로 조사되었다.

검색어: 해충, 예찰, 예측시스템, 감, 경북지역

P147

Transcriptome analysis of *Aphis gossypii* against *Beauveria bassiana* JEF-544

Ye Ram Im[1], So Eun Park[1], In Soo Jeon[1], Yu Lim Park[1], Yu Jin Jeong[1], Ki Jung Kim[1], Ga Hyeon Song[1], Jong Cheol Kim[1]and Jae Su Kim[1, 2]
[1]Department of Agricultural Biology, College of Agriculture & Life Sciences, Jeonbuk National University
[2]Department of Agricultural Convergence Technology, Jeonbuk National University

Cotton aphid, *Aphis gossypii* is a widely distributed pest of agricultural crops and acts as a vector of many serious plant viruses. Cotton aphid shows high resistance to chemical insecticides, and entomopathogenic fungi can be alternative to control cotton aphid. Here in this work, the early stage of response of cotton aphid to *Beauveria bassiana* JEF-544 was analyzed at transcriptome level. When JEF-544 infected aphids, a large proportion of aphid genes were up-regulated. From an enrichment analysis, insect hormone biosynthesis pathway was up-regulated. It seems that cotton aphid produces a large amaunt of energy to shed cuticles by actively producing insect molting hormone in the early stage of infection of *B. bassiana* JEF-544.

Key words: *Aphis gossypii*, cotton aphid, Beauveria bassiana, transcriptome, ecdysone

P148

Seasonal occurrence of *Ricania sublimata* and organic materials insecticidal activity on Omija(*Schisandra chinensis*) orchard in Gyeongbuk province

Min-Ki Kim, Won-Kwon Jung, Yang-Sook Lim, Jong-Soo Kim and Tae-Ryong Kwon
Gyeongbuk agricultural research and extension service

Ricania sublimata is rapidly occurrence and damage increasing in Gyeongbuk province Omija orchard. Therefore, in this study, the oviposition characteristics of the *R. sublimata* and the insecticidal activity against 8 organic materials. First oviposition showed in mid-August, the daily amount of oviposition was highest in mid-September. Last oviposition showed late October. The degree of ovipositon according to the height of cultivation of omija, most ovipositon occurred in branches with a height of 1.5-2 m. The egg masses were 15.8 cm long and laid opposite each other in two rows, and the number of eggs in the egg mass was 23.2, the length of the egg was 1.171 mm and the width was 0.536 mm. *R. sublimata* eggs, nymphs and adults were treated with 8 organic materials. As a result of insecticidal activity was machine oil 76.8% for eggs, sophora flavescens (matrine) 83.6% for nymphs and derris (rotenone) 76% for adults.

Key words: *Ricania sublimata*, occurrence, oviposition, organic materials, insecticidal activity

P149

Application of true skill statistics to evaluate CLIMEX performance

Sunhee Yoon[1] and Wang-Hee Lee[1,2*]
[1]Department of Smart Agriculture Systems, Chungnam National University
[2]Department of Biosystems Machinery Engineering, Chungnam National University

CLIMEX predicts the potential distribution of species based on climatic data, resulting in the Ecoclimatic Index (EI) that represents climatic suitability of species biology on a specific location. Compared to machine learning-based algorithms that use published model performance metrics, quantitative evaluation of CLIMEX performance is limited because of its mechanistic characteristics in modeling procedure. Therefore, this study attempted to develop a procedure for quantitatively evaluate the CLIMEX performance by applying true skill statistics (TSS) with determining the best EI threshold value. As a result, the TSS was varied according to the test area, while the optimal threshold EI values were similar regardless of the test region, showing possibility of TSS application in evaluating CLIMEX model performance.

Key words: CLIMEX, confusion matrix, model performance, optimal threshold, true skill statistics

P150

CLIMEX-MaxEnt ensemble modeling for predicting domestic spatial distribution of *Lymantria dispar* (Lepidoptera: Erebidae: Lymantriinae)

Jae-Woo Song[1], Jae-Min Jung[1], Sunghoon Jung[2,3] and Wang-Hee Lee[1,3]
[1]Department of Biosystems Machinery Engineering, Chungnam National University, Daejeon, 34134, Korea
[2]Department of Applied Biology, Chungnam National University, Korea
[3]Department of Smart Agriculture Systems, Chungnam National University, Daejeon, 34134, Korea

The gypsy moth (*Lymantria dispar*) is a forest pest which is distributed throughout the northern hemisphere. In 2020, outbreak of gypsy moth was occurred and caused wide range of damages in domestic trees as well as in human society, suggesting the precautionary evaluation of its distribution to prevent further damage. In this study, we developed an ensemble model to predict the spatial distribution of potential gypsy moth occurrence by using CLIMEX and MaxEnt. We evaluated climatic suitability in South Korea by using CLIMEX model that connects regional climate to species biology, while MaxEnt was used to predict occurrence possibility based on bioclimatic variables. Then, both models were spatially integrated by extracting consensus areas where showed high climatic suitability and occurrence possibility predicted by CLIMEX and MaxEnt, respectively, by using ArcMap. As a result, gypsy moth was predicted to occur most of South Korea under the current climate, but it would gradually decrease toward Gangwon-do according to climate change. In conclusion, model reliability was enhanced by integrating two algorithmically different models with potential projection of gypsy moth with application of climate change.

Key words: CLIMEX, ensemble modeling, MaxEnt, *Lymantria dispar*, spatial distribution

P151

Applying soil temperature in predicting spatial current potential distribution of *Pheidole megacephala* of South Korea

Se-Hyun Kim[1], Sunghoon Jung[2] and Wang-Hee Lee[1,3*]
[1]Department of Smart Agriculture Systems, Chungnam National University
[2]Department of Applied Biology, Chungnam National University
[3]Department of Biosystems Machinery Engineering, Chungnam National University

Pheidole megacephala, one of the worst tramp ant species originally from Africa, is a widespread pest in many tropical and subtropical areas. It negatively impacts native invertebrate faunas and agricultural production due to its rapid spread through human disturbance. In order to find potential risk regions of South Korea, species distribution modeling was done using CLIMEX model. Recent occurrence records from public database and previous research were cross-checked for building reliable model. Because *P. megacephala* dwells underground, soil temperatures of four depths (5, 10, 20, and 30 cm) were selected to analyze the underground habitat suitability. Statistical analysis of Growth Index and Ecoclimatic Index of CLIMEX model results were also done for predicting regions possible of future spread.

Key words: African big headed ant, CLIMEX, current distribution, *Pheidole megacephala*

P152

Population dynamics and biorational management of sucking insect pests on chilli

Mst. Fatema Khatun[1,3], Kyeong-Yeoll Lee[2] and Eui-Joon Kil[1]
[1]Department of Plant Medicals, Andong National University, Andong, Republic of Korea
[2]Institute of Agricultural Science and Technology, Kyungpook National University, Daegu, Republic of Korea
[3]Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh

We studied population fluctuations in relation to weather parameters and biorational management of sucking pests in chilli during 2020-2021. Studies have shown that sucking insects (aphids, jassids, whiteflies and thrips) are active throughout the year especially in vegetable crops. The highest number of sucking pests (24.65, 13.72, 14.83 and 62.28) was recorded in March and April at temperatures of 36.0°C and 35.0°C, respectively. There was a positive correlation between pest population and temperature, relative humidity and rainfall. The result also shows that the significant variation and R2 value indicate that biotic factor contributes to 14.9, 46.3, 7.1 and 0.67 variations in the population of thrips, jassids, whiteflies and aphids respectively. All regression models are significant for whiteflies, jassids and thrips and meet the model selection criteria. No significant regression model was found for the aphid population. Among the biorational measures, the lowest population of aphids (3.68), whiteflies (3.00), jassids (3.52) and thrips (3.40) was recorded in the spinosad 45SC treated plot followed by the untreated control. On the other hand, the highest mortality rate (68.89%, 72.01%, 66.69% and 69.20%) was also recorded in the spinosad 45SC treated plot. Spinosad 45SC is recommended for the control of sucking pest complex in chilli. Such studies are helpful in developing predictive models against sucking pests for their efficient control.

Key words: Sucking pests, population fluctuations, bio rational, pest management

P153

Investigation of occurrence and development of storage technology against Garlic bulbils pest

Seung ju Lee, Jong Woo Han, Ji Hyeon Min, Jae Hyun Jeong and Taek-Gu Jeong
Garlic & Onion Research Institute, Chungcheongbuk-do Agricultural research & Extension Services

마늘은 백합(Lilliaceae)과 알리움(*Allium*)속에 속하며 양념채소류에서 큰 비중을 차지하고 있다. 마늘은 영양체작물로 바이러스의 수직감염에 취약하며, 바이러스 감염을 줄이기 위하여 주아재배를 실시한다. 하지만 주아 저장 중 발생하는 해충에 대한 연구는 미비한 실정이다. 본 연구에서는 마늘 주아 저장시 해충의 발생생태를 조사하였으며, 해충의 피해를 경감시키기 위해 주아를 침지소독 후 해충의 발생밀도를 관찰하였다. 조사결과 마늘 주아 저장 중 파총채벌레, 파좀나방 2종의 해충이 발생하였으며, 시간이 경과함에 따라 밀도는 증가하였다. 파좀나방은 8월 상순, 파총채벌레는 7월 중순까지 출현하였으며, 약제 침지 후 발생밀도는 급격히 감소하는 것을 관찰하여 주아의 약제침지가 주아 저장 중 해충 방제에 효과적인 것을 확인하였다.

검색어: 마늘, 주아, 저장, 파총채벌레, 파좀나방

P154

Effect of pesticides on spatial and temporal dispersion of whitefly-predator/parasitoid in Paprika greenhouse

Meeja Seo, Hojun Rim, Jeong Hwan Kim, In Hong Jeong, Dagyeong Jeong, Gwan Seok Lee and Hong Hyun Park
Crop Protection Division, National Institute of Agricultural Sciences, RDA

In the winter cropping season of Paprika, powdery mildew as well as spider mites and whiteflies mainly occur at the same time. Therefore, selective pesticides are indispensable for successful control of various insect pests and pathogens in crops. In spite of weekly pesticide applications, the predatory mite, *Amblyseiulus swirskii* was maintained about 0.57 individuals per leaf by controlling whiteflies on 30 days after release. The mean number of whitefly adults captured on sticky trap in release and control plots were 18.1±4.3 and 21.1±4.6, respectively. On the other hand, it was difficult to find the parasitic wasp, *Eretmocerus eremicus* in greenhouse even after 10 days of release. The mean number of whitefly per trap in parasitoid release and control plots were 158.4±21.0 and 176.9±22.1, respectively. Our study have shown that *E. eremicus* was highly susceptible to pesticides used so that they couldn't settle down in the Paprika greenhouse. Consequently, the use of *E. eremicus* in combination with selected pesticides has been considered incompatible for reducing whitefly populations.

Key words: *Bemisia tabaci*, *Amblyseius swirskii*, *Eretmocerus eremicus*

P155

Effect of trap types and colors on trap catches of yellow peach moth, *Conogethes punctiferalis* (Lepidoptera: Crambibae)

Il Nam[1], Min Jung Huh[1], Jae-Woo Lee[1], Minwoo Lee[1], Dong Ho Lee[1], Kyungjoo Hwang[1], Soungbin Cho[1] and Il-Kwon Park[1,2]
[1]Department of Agriculture, Forest, and Bioresources College of Agriculture and Life Science, Seoul National University
[2]Research Institute of Agriculture and Life Science, College of Agriculture and Life Sciences, Seoul National University

To improve the efficacy of monitoring of *C. punctiferalis,* we investigated the effect of trap design and colors on the number of adult males caught in pheromone traps. No significant difference was observed in the number of male captures between bucket and delta traps. Trap colors affected the number of adult males caught in pheromone traps. An analysis of the relationship between trap capture and trap surface-color values (*L*a*b**) revealed a positive relationship between trap capture and *b** value. Using a yellow bucket trap baited with pheromones could improve the efficacy of monitoring of *C. punctiferalis.*

Key words: Yellow peach moth, Pheromone trap, Trap types, Trap colors

P156

Efficacy of insecticides for control of *Basilepta fulvipes* in the Indian dendranthema

Jae Min Seong, Han Sol Lee, Hye Jin Kim, Kwang Min Cho and Kee Woong Park
Daeseungbiofarm Co., Ltd,, Daejeon, 34127, Korea

Pesticides should be registered before use in pest management in accordance with PLS (positive list system) policy which has been implemented since 2019 in Korea. For the purpose of registration of the product, we evaluated the efficacy of five insecticides against *Basilepta fulvipes* in Sancheong-gun, Gyeongnam and Geumsan-gun, Chungnam provinces of Korea in 2021. *B. fulvipes* were collected from Geumsan-gun, and inoculated to the Indian dendranthema fields. The number of insects alive was counted on the day of application and, the third and seventh days after application. The average control values of Chlorfenapyr EC, Emamectin benzoate EC, Bifenthrin WP, Phenthoate EC, and Etofenprox EC for both sites were 92.1%, 96.8%, 92.6%, 96.9%, and 96.3%, respectively. Five insecticides tested in this experiment exhibited more than 90% control efficacy. Therefore, it is expected that the five commercial insecticides can be registered and used to control *B. fulvipes* in the Indian dendranthema fields in Korea.

Key words: *Basilepta fulvipes*, Indian dendranthema, PLS, Insecticides, Efficacy

P157

Insecticidal activity of secondary metabolites from *Streptomyces gramineus* against *Thrips palmi*

Sang Hee Kim[1], Dong Hwan Park[1], Jae Young Choi[2], Min Gu Park[2], Minghui Wang[1], Ho Yeon Lee[1] and Yeon Ho Je[1,2]
[1]Department of Agricultural Biotechnology, Seoul National University, Seoul, Republic of Korea
[2]Research Institute for Agriculture and Life Sciences, Seoul National University, Seoul, Republic of Korea

Thrips palmi is one of the severe pests damaging wide range of crops. Although predators and chemical pesticides have been used to control *T. palmi,* they showed low efficacy and various resistance cases have been reported. It was reported that streptomyces produce various insecticidal metabolites such as spinosad and avermectin, suggesting that streptomyces secondary metabolites could be a useful biological pesticde. In this study, 174 streptomyces culture filtrates were screened for insecticidal effect on *T. palmi*. Among them, streptomyces IMBL-2090 exhibited the highest insecticidal acticity. Through bioassay guided fractionation, the insecticidal substance was identified as phenyl acetic acid. These results suggested that streptomyces would be a novel biological pesticide to control *T. palmi*.

Key words: streptomyces, insecticidal activity, pesticide, *Thrips palmi*

P158

Screening and characterization of entomopathogenic fungi for the efficient control of bean bug, *Riptortus pedestris*

Thida Win, Jin Yong Lee, Hyun Soo Kim and Soo Dong Woo
Department of Agricultural Biology, College of Agriculture, Life & Environment Science, Chungbuk National University, Cheougju 28644, Korea

The *Riptortus pedestris* causes the greatest damage to soybean and has become serious problem due to high resistance to insecticides. To address this problem, the development of efficient bioinsecticides is a major focus for pest management. The purpose of this study was to select the most effective entomopathogenic fungi for the control of *R. pedestris*. Virulences were evaluated by using 60 isolates of entomopathogenic fungi, *Beauveria bassiana* and *Metarhizium anisopliae*. Based on these result, *B. bassiana* CN14S2W1 was expected as the most efficient isolate for control of bean bug.

Key words: *Riptortus pedestris*, Entomopathogenic fungi, *Beauveria bassiana, Metarhizium anisopliae*

P159

Transcriptome analysis of *Beauveria bassiana* JEF-410 infecting poultry red mite, *Dermanyssus gallinae*

So-Eun Park[1], Ye-Ram Im[1], In-Soo Jeon[1], Yu-Lim Park[1], Yu-Jin Jeong[1], Ki-Jung Kim[1], Ga-hyeon Song[1], Jong-Cheol Kim[1] and Jae Su Kim[1,2]
[1]Department of Agricultural Biology, College of Agriculture & Life Sciences, Jeonbuk National University, Korea
[2]Department of Agricultural Convergence Technology, Jeonbuk National University, Jeonju 54596, Korea

Red mite, *Dermanyssus gallinae,* is an insect that causes serious damages to the egg production process of chickens. Through previous studies, it was confirmed that entomopathogenic fungus JEF-410 shows high virulence against poultry red mites. To figure out the interaction between red mites and JEF-410, we analyzed the infecting fungi of *Bb* JEF-410 by RNA-seq. The total number of DEGs, including 1291 up-regulated and 2010 down-regulated ones, were identified. These DEGs are classified into GO categories by Gene Ontology (GO) analysis. After this step, KEGG pathway analysis was performed. This result can contribute to the development of insect control agents using entomopathogenic fungi.

Key words: *Beauveria bassiana, Dermanyssus gallinae,* Entomopathogenic fungi, Transcriptome analysis

P160

Preliminary study of cold treatment on export grapes to disinfest *Pseudococcus comstocki* (Homoptera: Pseudococcidae) eggs

Dongbin Kim[1], Tae Hyung Kwon[1], Ki-Jeong Hong[2], Gi-Myon Kwon[3] and Byung-Ho Lee[1]
[1]NGS Core Research Center, Kyungpook National University
[2]Department of Plant Medicine, Sunchon University
[3]Bio Utilization Institute, Andong

Pseudococcus comstocki, might cause a quarantine problem in exportation of grapes to South-East Asian countries. A new phytosanitary treatment using alternatives to methyl bromide (MB) could be required to overcome issues and further export promotion. When applied cold treatments with different exposure time (1 to 4 weeks) at 2 ℃ in preliminary studies, the hatching rate of inoculated *P. comstocki* eggs on grapes was 0% for 4 weeks and there were no significant phytotoxic damages on grapes in terms of weight loss, sugar contents and color changes compare to untreated. Cold treatment on exported grapes could be alternative option to replace current phasing-out MB treatment and further scaled-up trials and related research on combined with fumigation to reduce treatment time is required.

Key words: *Pseudococcus comstocki*, export grapes, cold treatment, phytotoxic assessments

P161

Analysis of *Bacillus thuringiensis* subsp. *japonensis* CAB452 crystal protein with activity on *Bradysia agrestis*

Hee Ji Kim[1], You Kyoung Lee[2], Hyun Ko[1] and Young Nam Youn[1]
[1]Department of Applied Biology, College of Agriculture and Life Sciences, Chungnam National University
[2]Division of Crop Foundation, National Institute of Crop Science

작은뿌리파리에 살충활성이 있는 *B. thuringiensis* subsp. *japonensis* CAB452 균주와 대조균주로 *B. thuringiensis* subsp. *japonensis* 균주를 사용하여 plasmid DNA 패턴을 확인한 결과 *B. thuringiensis* CAB452 균주는 1개의 23.1 kb보다 큰 plasmid DNA 밴드를 확인하였고, 대조균주와 비슷한 양상을 나타났다. *B. thuringiensis* CAB452 균주가 가지고 있는 내독소 단백질 유전자 중에 파리목에 활성이 거의 없는 *B. thuringiensis* subsp. *japonensis* BuiBui 기준균주가 가지고 있지 않고, 지금까지 발견되어 *B. thuringiensis* Toxin Nomenclature Database에 기록되어 있는 유전자들과 비교하였을 때 유사성이 낮은 cry1Ie1, vip3Aa4 유전자로 인해 작은뿌리파리 유충에 살충활성을 가지는지 여부를 확인하고자 cry1Ie1, vip3Aa4 유전자를 각각 cloning 하였다. *B. thuringiensis* Cry-B transformant를 pHT1K-cry1Ie/Cry-B, pHT1K-vip3Aa4/Cry-B로 명명하였다. 발현된 pHT1K-cry1Ie/Cry-B, pHT1K-vip3Aa4/Cry-B은 *B. thuringiensis* CAB452 균주와 동일한 spherical 형태의 parasporal을 생성하였다. Cry1Ie1, vip3Aa4 유전자만 가지고 있는 pHT1K-cry1Ie1/Cry-B와 pHT1K-vip3Aa4/Cry-B에 대하여 작은뿌리파리 유충에 활성검정을 한 결과, CAB452 균주의 경우 10^8cfu/ml에서 LC_{50}값은 1.8×10^6cfu/ml으로 나타난 반면, pHT1K-cry1Ie1/Cry-B의 경우 LC_{50}값은 8.0×10^8cfu/ml으로 나타났고, pHT1K-vip3Aa4/Cry-B의 경우 LC_{50}값은 1.3×10^9cfu/ml으로 *B. thuringiensis* CAB452 균주보다 다소 낮은 살충활성을 가지는 것으로 나타났다.

검색어: 작은뿌리파리, *Bacillus thuringiensis*, 생물적 방제, 형질전환

P162

Construction of an improved *Bacillus subtilis* strain to control pests and plant diseases

Ho Yeon Lee[1], Min Gu Park[2], Jae Young Choi[2], Dong Hwan Park[1], Minghui Wang[1], Sang Hee Kim[1] and Yeon Ho Je[1,2]

[1]Department of Agricultural Biotechnology, Seoul National University, Seoul, Republic of Korea
[2]Research Institute for Agriculture and Life Sciences, Seoul National University, Seoul, Republic of Korea

The extensive use of chemical insecticides leads to an accumulation of pesticide residues in agricultural fields. It brings out severe environmental problems including insecticide-resistant pests. For this reason, there have been many attempts to replace chemical pesticides with microbial biopesticides. *Bacillus thuringiensis* (Bt) has been broadly used in agriculture for the control of pests. In the previous study, to improve insecticidal activities, the recombinant Bt plasmid that pMBD-ABC was constructed which is simultaneously encoding *cry1Ac*, *cry1Be* and *cry1C* insecticidal proteins genes. In this study, the pMBD-ABC was introduced into a *Bacillus subtilis* strain which has high antifungal activities against *Sclerotinia sclerotiorum*, *Botrytis cinerea* and *Colletotrichum acutatum*. These results suggest that the recombinant *B.subtilis* could be dual-functional biopesticides to control insect pests and plant fungal diseases at a time.

Key words: *Bacillus thuringiensis*, *Bacillus subtilis*, antifungal activity, insecticidal proteins

P163

Insect juvenile hormone disruptors that affects the development of *Drosophila melanogaster* larvae

Jun Hyoung Jeon[1], Seon-Ah Jeong[1], Sang-Woon Shin[2], Doo-Sang Park[1], Ji-ae Kim[2], Hong-Hyun Park[3] and Hyun-Woo Oh[2]

[1]Biological Resource Center, Korea Research Institute of Bioscience and Biotechnology
[2]Core Facility Management Center, Korea Research Institute of Bioscience and Biotechnology
[3]Crop Protection Division, National Academy of Agricultural Science, RDA

Many plant species possess compounds with juvenile hormone disruptor (JHD) activity. we demonstrate that a plant extract interfere with the formation of both methoprene-tolerant (Met)/Taiman heterodimer complexes in yeast two-hybrid assays *in vitro*. Here, we use medicine herbs extract one of the plant extracts, 880 medicinal herbs extract were treated in the Met/Taiman heterodimer complexes to select JHD, and curcumin lineage was selected as a highly active substance. In addition, to the *in vitro* JHD activity, the medicinal herbs extract from curumin lineage also disrupt the development of larvae in *Drosophila melanogaster*.

Key words: Juvenile hormone, Methoprene-tolerant, Taiman, Yeast two-hybrid assay, Curcumin

P164

The performance of *Aphis gossypii* on different cucumber cultivars and its effects on biological control by parasitoid, *Binodoxys communis*

Hojun Rim, Honghyun Park and Meeja Seo
Crop Protection Division, National Institute of Agricultural Sciences, RDA

In this study, we tried to clarify to what extent the difference of performances of the cotton aphid, *Aphis gossypii* on host plant cultivars affects biological control using parasitoid, *Binodoxys communis*. First, we experimented the performance of *A. gossypii* on two cucumber cultivars, Gangryeogsamcheok and Baekbongdadagi. The aphid reproduced more on Gangryeogsamcheok than Baekbongdadagi. In each acryl cage, 20 aphids were inoculated on each cucumber cultivar and then different pairs of *B. communis* were released on 2 days after inoculation. On Baekbongdadagi, aphid population was not controlled and increased up to 600 nymphs when 2 pairs of *B. communis* were released. In case of 3 or 4 pairs of parasitoids release, aphid population maintained about 200 nymphs. On the other hand, aphid population quickly decreased and maintained under the 100 nymphs on Gangryeogsamcheok even when only 2 pairs of parasitoid were released.

Key words: *Binodoxys communis, Aphis gossypii,* cucumber, biological control

P165

Development of next-generation insect pest control technique with improved efficiency using ultra-fine porous aluminosilicate structures

Dong Kyun Seo[1] and Young Ho Koh[2]
[1]Biodesign Center for Molecular Design & Biomimetics, Arizona State University, Tempe, AR, USA
[2]Ilsong Instiute of Life Science, Hallym University, Seoul., Korea

Recent studies have reported that food additives, which are almost non-toxic to humans and the environment, are toxic to insect pests. In addition it has been reported that species-specific pest control techniques can be developed using double-stranded RNA for important signaling genes. The biggest known problem of these new eco-friendly pest control techniques is control efficiency. In order to increase their pest control efficiency, it is necessary to develop a method for efficiently delivering food additives or ds-RNA into the body of insect pests. In this study, we investigated how to use various ultra-fine porous aluminosilicate structures to increase the insecticidal efficiency of various food additives and ds-RNAs (RDA Grant No. PJ014845).

Key words: Insect pests, food additives, ds-RNAs, ultrafine porous structures, aluminosilicate

P166

Juvenile hormone inhibitory and mosquito larvicidal substances derived from actinomycetes

Dong Hwan Park[1], Jae Young Choi[2], Min Gu Park[1], Minghui Wang[1], Sang Hee Kim[1], Ho Yeon Lee[1] and Yeon Ho Je[1,2]

[1]Department of Agricultural Biotechnology, Seoul National University, Seoul, Republic of Korea
[2]Research Institute for Agriculture and Life Sciences, Seoul National University, Seoul, Republic of Korea

Mosquito-borne diseases are major threat to public health in worldwide. However, excessive use of conventional insecticides for vector control causes environmental and resistance problem. Juvenile hormone antagonists (JHAN) have potential to become alternative insecticides due to their high specificity. Recently, it was reported that actinomycetes produce insecticides with JHAN activity. In this study, using high throughput JHAN screening system, secondary metabolites of actinomycetes were screened for their JHAN activity and mosquito larvicidal activity. Among them, four strain was selected for their JHAN and mosquito larvicidal activity. Selected actinomycetes were investigated for their characteristics.

Key words: Actinomycetes, *Aedes albopictus*, juvenile hormone antagonist

P167

The mosquito control of evidence-based using DMS

Chang-Won Jang, Hyunwoo Kim, Gi-Hun Kim, Sun-Ran Cho and Hee Il- Lee
Division of Vectors and Parasitic Diseases, Korea Disease Control and Prevention Agency (KDCA)

전국 시·도 보건소에서는 감염병 매개모기 밀도를 감소시키기 위해 다양한 방법으로 방제 활동을 수행하고 있으나, 대부분의 보건소에서는 관행적으로 주기적인 방제를 수행하고 있다. 본 연구에서는 주기적인 방제에서 근거 중심의 선택적인 방제로 전환하고자 일일모기발생감시장비(DMS)를 활용하였다. 수행지역은 천안시 서북구보건소 인근에 설치된 DMS 5대 지점을 중심으로 반경 100 m 내 모기 서식지를 조사하였고, 방제 시기 및 효과 확인은 DMS에 채집된 모기 발생 밀도에 따라 결정하였다. 그 결과, `21년도 모기 대발생 시기인 8~9월 방제 횟수는 전년 대비 평균 69.0% (총 29회→9회) 감소하였고, 전체 모기 민원 수는 전년 대비 43.8% (48건→27건) 감소하였다. 따라서, DMS를 활용하여 모기 발생 밀도를 확인함으로써, 기존의 관행적이고 주기적인 방제에서 근거 중심의 선택적 방제로 전환이 가능할 것으로 판단된다.

검색어: 모기 밀도 감시, 모기 방제, 일일모기발생감시장비(DMS)

P168

Greenhouse temperature management for the predatory mite establishment in the summer season

Seon-U Choi, Eun-Ju Song, Chang-Kyu Lee, Hy0-Jung Choi, Sang-Young and Min-Sil An
Jeollabuk-do Agricultural Research and Extension Services

고온기 천적 지중해이리응애 정착을 위한 시설하우스 내부 온도를 40℃ 이하로 설정하는 것을 추천한다. 우리나라는 여름철 고온으로 시설재배지에서 천적이 정착하기 어렵다고 알려져 있지만, 고추, 파프리카 등 다양한 작물이 여름철에 재배가 되고 천적을 활용하고 있어 고온기 천적 활용을 위한 온도 설정 제시가 필요하다. 실내실험으로 지중해이리응애를 25℃에서 40℃까지 5℃ 간격으로 4처리한 결과, 생존율은 25℃에서 가장 높았고 처리온도가 높아질수록 낮아졌고 40℃에서는 처리후 1일차부터 100% 생존하지 못함을 확인하여 온도가 상승할수록 생존이 어려움을 보여준다. 농가하우스의 온도를 조사한 결과, 7월의 하우스 일중 평균온도가 40℃ 안팎 이하로 나타나는 곳에서 지중해이리응애를 확인할 수 있었으나 45℃ 이상 평균온도를 유지하는 시설하우스에서 지중해이리응애를 확인할 수 없었다. 실내시험 결과와 온실 결과를 종합하였을 때 40℃이상인 경우는 이리응애 생존이 어렵다고 판단된다. 본 시험 결과가 고온기 시설하우스 내 천적활용 농가 애로사항을 해결할 수 있기를 기대한다.

검색어: 천적, 지중해이리응애, 고온기, 온도 관리

P169

Insect monitoring in field-cultivated pepper

Mi Hye Seo, Sun-Young Lee and Jung, Beom Yoon
Horticultural & Herbal Crop Environment Division, NIHHS, RDA, Korea

기후변화에 따른 노지 고추에 발생하는 주요 해충의 발생 양상과 변동 분석을 위해 시기별 발생 밀도를 조사하였다. 고추 재배기간인 5~9월까지 전북 고창, 충남 청양, 충북 괴산지역 노지고추 포장에서 2주 간격으로 황색끈끈이트랩을 이용하여 주요 해충 발생현황을 조사하였다. 주로 총채벌레, 담배나방, 진딧물이 발생하였으며 담배나방은 주로 7월 하순, 8월 상순~중순, 9월 상순에 피해가 컸다. 총채벌레는 6월 상순부터 증가하기 시작하여 7월 중순에 밀도가 가장 높았다. 시기별로 총채벌레를 채집하여 동정한 결과 꽃노랑총채벌레, 대만총채벌레, 파총채벌레의 발생이 확인 되었다. 이들 3종 중 대만총채벌레가 시기별로 가장 발생 밀도가 높은 것으로 보아 우점종으로 보여진다. 노지 고추에서 총채벌레는 6월 상순 이전부터 모니터링하고, 담배나방은 연 4회에 걸쳐 살충제를 살포하는 방제전략을 수립하는 것이 좋을것으로 판단된다

검색어: 노지, 고추, 총채벌레, 담배나방, 발생

P170

Insecticidal activities of host-derived dsRNAs against *Spodoptera exigua*

Minghui Wang[1], Jae Young Choi[2], Min Gu Park[1], Dong Hwan Park[1], Sang Hee Kim[1], Ho Yeon Lee[1] and Yeon Ho Je[1,2]

[1]Department of Agricultural Biotechnology, Seoul National University, Seoul, Republic of Korea
[2]Research Institute for Agriculture and Life Sciences, Seoul National University, Seoul, Republic of Korea

Spodoptera exigua (beet armyworm) is a main pest in agricultural production. Due to its high resistance to the conventional pesticide, it is hard to control effectively. Therefore an effective way is necessary. RNA interference (RNAi) has already been applied on the gene function research and it is also considered to have the potential for controlling the pest due to its specific silencing ability. According to the reference research and relevant experiments, several genes, which are reported to be effective to control of *S. exigua*, has been selected as the target of dsRNA. In this study, the selected dsRNAs has been synthesized and applied to the *S. exigua* larvae with several combinations. The dsRNAs targeted to *S. exigua* β1 integrin and *S. exigua* apolipophorin III has showed the highest insecticidal activities. In the next study, these genes will be introduced into the baculovirus DNA for making a more useful insecticide.

Key words: RNA inference, *Spodoptera exigua*, β1 integrin, apolipophorin III

P171

Selecting insecticides for efficient control on cabbage seed pod weevil of a small cultivated crop, *Brassica napus*

Hyun-woo Sim[1], Ha yong Choi[2], Ja lang Lim[2], Myeong whan Kim[2], Jun ho Kim[2] and Sora Kim[1]

[1]Department of Plant Protection & Quarantine, Graduate School of Plant Protection & Quarantine, Jeonbuk National University
[2]Insecticide team, Plant Protection Institute

유채(*Brassica napus* Linne)는 중국 원산의 두해살이풀로 키는 1m 정도이다. 최근 경관단지 조성, 바이오 디젤 원료등으로 많이 이용되고 있어 일본, 중국, 한국에서 재배면적이 늘고 있다. 현재 우리나라에서는 소면적으로 재배하고 있다. 유럽좁쌀바구미(*Ceutorhynchus obstrictus*)는 유럽이 원산지이나, 국내 침입하여 특히 유채축제가 매년 행해지고 있는 전남지역에서 대발생 , 그 발생 분포가 점점 확대되고 있다. 시중에 판매 되고 있는 농약들은 재배 면적과 높은 수요량을 가진 작물 위주로 개발되어 소면적 재배를 하고 있는 농가에서는 PLS제도로 인해 등록되어 있지 않은 약제를 사용할 수 없어 등록농약의 부족으로 병해충 방제에 어려움을 겪고 있다. 유채 유럽좁쌀바구미도 약제방제를 위하여 이용할 수 있는 살충제가 거의 없는 실정이다. 또한 유럽좁쌀바구미의 약효조사 방법이 설정되어 있지 않다. 본 연구는 유채를 가해하는 유럽좁쌀바구미의 신속한 방제를 위해 타작물에 효과가 입증된 농약 중 유럽좁쌀바구미 방제에 탁월한 농약을 선발하고 효율적인 약효조사를 위한 방법을 선택하기 위해 실험을 실시하였다.

검색어: 유채, PLS제도, 소면적, 방제, 유럽좁쌀바구미

P172

Occurrence of lepidopteran insect pests on urban forests

Sujin Lee[1], Soojeong Ahn[2], Junheon Kim[1] and Samg-Tae Seo[1]
[1]Forest Entomology and Pathology Division, National Institute of Forest Science
[2]Erang Bio-Environment Research System

In order to establish an effective pest control strategy, this study that investigation of the occurrence of lepidopteran pests in the major trees of urban forests from 2019 to 2021, was carried out. It was confirmed that 76 species of 14 families in *Prunus* spp., 43 species of 10 families in *Zelkova serrata*, 40 species of 8 families in *Acer* spp., 28 species of 7 families in *Rhododendron* spp., and 10 species of 4 families in *Hibiscus* spp. were found. Among them, *Hyphantria cunea* and *Lymantria dispar* were occurred in all five tree species studied. The most frequent occurrence species in each tree were as follows: *H. cunea* and *Phalera flavescens* in *Prunus yedoensis*, *Epinotia ulmicola* in *Z. serrata*, and *Rehimena surusalis* in *Hibiscus* spp. *H. cunea* also occurred in *Rhododendron* spp. and *Acer* spp., although the number of them was not as high as those in *Prunus* spp. and *Z. serrata*. Therefore, our results showed that it is necessary to pay attention to the occurrence frequency of lepidopteran pests in *Prunus* spp. and *Z. serrata*, but in the case of both *Acer* spp. and *Rhododendron* spp. was less problematic. Taken together, the use of pheromones for monitoring lepidopteran and using mate disruptor would be desirable to minimize the spraying of pesticides in urban forests while considering the risks to human health.

Key words: urban forest, lepidopteran, control strategy, pheromone

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Identification of a sex pheromone of *Anomis privata* (Lepidoptera: Noctuidae)

Sujin Lee, Heejung Kim,Keonhee E. Kim,Junheon Kim and Sang-Tae Seo
Forest Entomology and Pathology Division, National Institute of Forest Science

Anomis privata (Lepidoptera: Noctuidae), is one of the primary defoliator insects on *Hibiscus* spp. in Korea. The moths of this family are difficult to detect without pheromone traps due to being active at night. To develop a suitable tool for monitoring this pest in *Hibiscus syriacus*, we investigated the attractiveness of sex pheromone to *A. privata* adults. We performed gas chromatography-mass spectrometry (GC-MS) analysis of female abdominal tip extracts and identified 7-methylheptadecane (7-MeC17) as a major component of sex pheromone candidate. 7-MeC17 was chemically synthesized and were tested for field attractancy. Male *A. privata* were captured in 7-MeC17 baited traps from April to August in Seoul and Suwon, Korea in 2021. In field tests, traps baited with 7-MeC17 attracted significantly more males than those with hexane as control. Based on these results, it was revealed that 7-MeC17 is one of pheromone components of *A. privata*. And it suggests that 7-MeC17 could be useful in a monitoring strategy, which can determine an accurate assessment of the threshold for insecticide applications of target insects.

Key words: *Anomis privita*, *Hibiscus syriacus*, Sex pheromone, 7-methylheptadecane, Monitoring

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Feeding behavior analysis of *Nilaparvata lugens* and *Sogatella furcifera* (hemiptera: Delphacidae) by sublethal concentration of imidacloprid and sulfoxaflor

Yeolgyu Kang, Hyun-Na Koo and Gil-Hah Kim
Department of Plant medicine, Chungbuk National University

벼멸구(*Nilaparvata lugens*)와 흰등멸구(*Sogatella furcifera*)는 매년 중국 남부로부터 비래하여 국내로 유입되는 해충이다. 두 종 모두 흡즙성 해충으로 벼를 흡즙하여 피해를 준다. 본 연구에서는 멸구류의 화학적 방제를 위해 사용되는 살충제인 imidacloprid, sulfoxaflor, dinotefuran 등 10개 약제의 추천농도에 대한 벼멸구와 흰등멸구의 살충 활성을 평가하였다. 그 중 imidacloprid와 sulfoxaflor에 대한 벼멸구와 흰등멸구의 아치사농도(LC_{10}, LC_{30})를 각각 산출한 후 이에 따른 섭식 행동을 비교하기 위해 EPG (Electrical penetration graph)를 이용하였다. 그 결과 벼멸구와 흰등멸구의 체관 섭식 파형 N4-b는 두 약제 모두 무처리구에 비해 유의하게 감소하였으나 물관 섭식 파형 N5는 유의성이 없었다. 비탐침 파형인 NP의 경우 무처리구에 비해 약제 처리구에서 더 길게 나타났다.

검색어: 벼멸구, 흰등멸구, EPG, 아치사농도, 섭식행동

P175

Synergistic effect by sequential treatment of phosphine and cold temperature against *Drosophila suzukii* (Diptera: Drosophilidae)

Seung-Ju Seok[1], Bong-Su Kim[2], Hyunkyung Kim[1], Hyun-Na Koo[1] and Gil-Hah Kim[1]
[1]Department of Plant Medicine, Chungbuk National University, Korea
[2]Plant Quarantine Technology Center

벗초파리는 수확 전 신선한 과일에 상처를 내어 감염하며, 수확 후에도 2차 적인 피해를 유발시켜, 경제적인 피해를 일으킨다. 저온 단독 처리시, 5℃보다 1℃에서 효과가 높았으며, 성충이 가장 내성을 나타내었다. 그러나 포스핀(PH_3) 단독처리에서는 성충이 가장 감수성을 나타내었으며 번데기는 가장 내성을 보였다. 포스핀과 저온 병행처리에서, 알을 제외하고는 저온+PH_3보다 PH_3+저온 처리가 효과적임을 확인하였다. 포스핀 단독 처리에서 모든 발육 단계 중 가장 내성이 강한 번데기의 LCT_{99}값의 상승률은 1℃에서는 2.45배, 5℃에서는 1.42배로 나타났다.

검색어: 벗초파리, 저온처리, 포스핀, 훈증, 복합처리, 상승효과

P176

Synergistic effect of ethyl formate fumigation with cold temperature treatment against *Drosophila suzukii* (Diptera: Drosophilidae)

Jong-Chan Jeon[1], Bogn-Su Kim[2], Hyun- Kyung Kim[1], Hyun-Na Koo[1] and Gil-Hah Kim[1]
[1]Department of Plant Medicine, Chungbuk National Univesity, Cheongju 28644, Korea
[2]Plant Quarantine Technology Center

벗초파리(*Drosophila suzukii*)에 대한 에틸포메이트(Ethyl formate, EF) 훈증과 저온처리의 복합사용의 상승효과를 평가하였다. LCT_{50}값 수준의 훈증제 농도를 1℃ 저온처리 전, 후에 처리하였다. 그 결과, 훈증제 처리 후 저온처리가 가장 좋은 효과를 나타내었다. 이후 단독 저온처리와 훈증제 처리 후 저온처리를 비교한 결과 100% 방제를 위한 저온처리 기간이 단축되었다. 따라서 EF와 저온조건의 복합처리를 통해 더욱 효과적인 벗초파리 방제가 가능할 것으로 기대된다.

검색어: 벗초파리, 에틸포메이트, 훈증, 저온처리

P177

Spatial distribution of *Apis mellifera* (Hymenoptera: Apidae) during winter

Sara Park, Siwoo Lee and Hye-Kyung Kim
Department of Industrial Entomology, Korea National College of Agriculture and Fisheries

Honey bee is one of most important insects as a pollinator, a producer, and a case insect of social insect studies in the world. The colony collapse disorder of this important honey bees has been frequently reported in the world. Recently, this phenomenon was reported in Korea during winter. Thus, this study was conducted to understand the population dynamics of honey bees within a beehive. For experiment, a beehive with five frames was used. Within the beehive, there were an newly mated queen and approximately 10,000 worker bees. Pupa locations within a hive were observed and recorded every week from December 29th, 2021 to March 30th, 2022 after three week settlement periods of newly placed hive. Its population dynamics were analyzed with SADIE (spatial analysis by distance indices) and mapped with ArcGIS. The population of heneybees with the hive started to be established from the middle and spread to edges within a frame and the hive. The spatial relationship between the density of pupa and temperatures within the hive were also analyzed. This information would be helpful to understand the population dynamics of honeybees within a hive and to preserve its populations during winter.

Key words: *Apis mellifera*, honey bee, overwintering, spatial analysis, population dynamics

P178

Whole-genome sequences of 37 breeding line *Bombyx mori* strains and their phenotypes established since 1960s

Seong-Wan Kim[1†], Min Jee Kim[2†], Seoung-Ryul Kim[1], Jeong Sun Park[2], Kee-Yong Kim[1], Ki Hwan Kim[3], Woori Kwak[4*] and Iksoo Kim[2*]

[1]Department of Agricultural Biology, National Academy of Agricultural Science, Rural Development Administration,
[2]Department of Applied Biology, College of Agriculture & Life Science, Chonnam National University,
[3]Gencube Plus
[4]Hoonygen

The National Institute of Agricultural Sciences of the Rural Development Administration of Korea (NIAS, RDA, Korea) has been collecting silkworm resources with various phenotypic traits from the 1960s and established breeding lines for using them as genetic resources. In this study, we report the whole-genome sequences of 37 breeding line *B. mori* strains established over the past 60 years, along with the description of their phenotypic characteristics with photos of developmental stages. In addition, we report the example phenotypic characteristics of the F1-hybrid strain using these breeding line strains. We hope this data will be used as valuable resources to the related research community for studying *B. mori* and similar other insects.

Key words: domesticated silkworm, phenotype, Whole-genome, F1-hybrid strain, breeding line

[†]These authors equally contributed to this study.

P179

Effect of mealworm(*Tenebrio molitor*) medium to cultivation of *Cordyceps militaris*

Sang-Sik Lee[1], Ju-Rak Lim[1], Eun-Jin Lee[1], Jun-Hee Nam[1], Woong Kim[1] and Chang Hak Choi[2]

[1]Sericulture and Entomology Experiment station, Jeollabuk-do A.R.E.S., Buan 56339, Korea
[2]Seed & Variety Service offise, Jeollabuk-do A.R.E.S., Iksan 54531, Korea

Edible insects, which are valuable as the food of the future, have low consumer's perception due to their hateful appearance. In order to improve consumer's perception and expand the edible insects market, this study was conducted on cultivation of *Cordyceps militaris* fruiting body using a mealworm(*Tenebrio molitor* larvae). Based on the cultivation method of *C. militaris* using brown rice, we investigated the larvae admission type, amount, and inoculation amount of *C. militaris* spawn into 850㎖ polypropylene(PP) culture bottle. As a result, the larvae medium for growth of *C. militaris* were measured to have a 23% higher content of cordycepin, functional component, than the grain medium. when compared the larvae type of raw and dry, the raw larvae ware excellent in the fruit body number and length. In addition, when compared the larvae amount of 10, 20, 30, and 40g into 850ml culture bottle, the cultivation of fruit body was excellent at 30g.

Key words: Entomopathogenic Fungi, *Cordyceps militaris*, Mealworm, Cordycepin, cultivation

P180

Characteristics of development of *Protaetia brevitarsis*(Coleoptera: Cetoniidae) in different fermentation periods

Ju Rak Lim, Sang-Ssik Lee, Eun-jin Lee, Jun-Hee Nam, Woong Kim, Chang-Hak Choi and Hee-Jun Kim
Sericulture and Entomology Experiment Station, Jeonbuk Agricultural Research & Extension Service

베리류(뽕나무, 복분자, 블루베리) 전정가지를 톱밥으로 발효시켜 흰점박이꽃무지 먹이원으로 사용하고 발육특성을 조사하였다. 톱밥발효기간은 40일과 60일 처리하였고, 90일간 발효시킨 참나무톱밥과 비교하였다. 발육특성 조사결과 흰점박이꽃무지 유충 령기별 발육기간은 참나무발효톱밥에 비해 베리류톱밥에서 짧았고, 60일 발효시킨 베리류톱밥에서 가장 짧았다. 사망률은 5% 이내로 차이가 없었다. 흰점박이꽃무지 유충 발육속도는 베리류톱밥에서 참나무톱밥에 비해 빠르고, 40일 정도면 3령이 되었으며, 참나무톱밥에서는 70일 정도 걸렸다. 톱밥종류별 성충의 평균산란수는 큰 차이가 없었고, C/N율은 참나무발효톱밥에 비해 낮았으며, 중금속은 검출되지 않았다.

검색어: 흰점박이꽃무지, 발효기간, 베리류톱밥, 참나무톱밥, 발효톱밥

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Characteristics and efficacy evaluation of novel transgenic cell line

Kyu Seek Kim, Jun Su Bae, Hyun Soo Kim, Hyuk Jin Moon, Do Young Kim and Soo Dong Woo
Department of Agricultural Biology, College of Agriculture, Life & Environment Science, Chungbuk National University, Cheougju 28644, Korea

Baculovirus는 현재 외래단백질 발현에 널리 사용되어지고 있으며, 재조합 단백질을 생산하기 위해서는 긴 시간과 높은 숙련도를 요구하는 재조합 바이러스의 정량(Titration)이 필수적이다. 손쉬운 정량이 가능한 새로운 형질전환 세포주 Sf9-QE 세포주가 보고되었으나, 이 세포주에 대한 생물학적 특성 평가 및 실효성 평가가 이루어지지 않았다. 본 연구에서는 새로운 형질전환 곤충세포주 Sf9-QE 세포주에 대하여 Sf9 세포주와 생물학적 특성을 비교하였고, 다양한 바이러스를 이용해 실효성 평가를 실시하였다. 그 결과 Sf9-QE 세포주는 Sf9 세포주 대비 정량에 소요되는 시간이 절반이상 단축되었으며, 감염 시 발현되는 형광으로 인한 정량의 손쉬운 확인이 가능해졌다. 이로 인해 재조합 베큘로바이러스의 정량에 요구되는 긴 시간과 높은 숙련도에 대한 문제가 해결될 것으로 기대된다.

검색어: Baculovirus, Transgenic cell line, Virus titration, Sf9

P182

Prevalence of disease in *Allomyrina dichotoma* and *Protaetia brevitarsis* of insect rearing farms in Korea, 2019~2021

Kyu-Won Kwak, Yong-Soon Kim and Eunsun Kim
Industrial Insect and Sericulture Division, Department of Agricultural Science, RDA

곤충사육 농가를 대상으로 2019년도부터 2021년까지 주요 곤충병원성 바이러스, 세균, 진균 등 질병 발생 조사를 수행하였다. 주요 질병진단 항목은 바이러스 1종, 세균 3종, 진균 2종 등이었다. 2019년도에 장수풍뎅이는 12건이 장수풍뎅이누디바이러스(*Oryctes rhinoceros* Nudivirus)로 확인되었고 흰점박이꽃무지는 3건이 진균병(*Metarhizium anisopliae*)으로 확인되었다. 2020년에 장수풍뎅이의 누디바이러스는 5건이 확인되었으며, 흰점박이꽃무지의 진균병은 2건으로 확인되었다. 2021년도에 장수풍뎅이의 누디바이러스는 1건이 확인되었으며, 흰점박이꽃무지의 진균병은 확인되지 않았다. 2021년도에 장수풍뎅이와 흰점박이꽃무지의 질병 발생 건수는 총 7건으로, 장수풍뎅이 누디바이러스는 2019년 대비 83% 감소, 2020년 대비 약 60% 감소하였다. 흰점박이꽃무지의 진균병은 2019년 대비 약 33% 감소, 2020년 대비 50% 감소하였다. 이러한 질병 발생의 감소는 2020년도 초부터 발생한 국내 Covid-19로 인한 이동 제한에 따른 병원균 확산 감소와 사육 농가의 질병 관리를 위한 노력 등으로 생각된다.

검색어: 곤충질병, 장수풍뎅이 누디바이러스, 흰점박이꽃무지 진균병

P183

Molecular diagnosis of commercial silkworm powder products using single nucleotide polymorphisms in mitochondrial genome sequences by the tetra-primer ARMS PCR

Jeong Sun Park[1], Su Min Park[1], Seong-Wan Kim[2], Kee-Young Kim[2], Seong-Ryul Kim[2] and Iksoo Kim[1*]
[1]Department of Applied Biology, Chonnam National University
[2]Department of Agricultural Biology, Rural Development Administration

누에가루의 항당뇨를 비롯한 다양한 효과에 기인하여 다양한 건강기능식품이 판매되고 있는 실정이다. 시판 중인 건강기능식품의 관리를 위하여 추천된 누에 품종의 사용이 중요하며, 원산지 추적 및 원료 확인 등은 중요한 문제로 이를 위해 각각의 누에 품종을 구분할 수 있는 마커 개발이 필요한 실정이다. 본 연구에서는 가장 높은 빈도로 이용되는 10개 누에 품종을 대상으로 완전 mitochondrial genome 서열을 확보하여 비교하였으며, 그 결과 총 34개의 single nucleotide polymorphism (SNP)을 확인하였다. 그 중 대박잠, 골든실크, 금강잠, 백황잠, 백옥잠, 및 대황잠 등 6개 품종에서 품종 특이적 SNP가 존재하여, 이들 SNP를 대상으로 tetra-primer amplification refractory mutation system PCR(tetra-primer ARMS-PCR)법을 이용한 진단법을 개발하였다.

검색어: 누에, Mitochondrial genome, SNP, 분자진단

P184

Molecular identification of the strains of the domestic silkworm, *Bombyx mori* (Lepidoptera: Bombycidae) based on mitochondrial genome sequences

Jeong Sun Park[1], Min Jee Kim[1,2], Seong-Wan Kim[3], Kee-Young Kim[3], Seong-Ryul Kim[3] and Iksoo Kim[1*]
[1]Department of Applied Biology, Chonnam National University
[2]Honam Regional Office, Animal and Plant Quarantine Agency
[3]Department of Agricultural Biology, Rural Development Administration

Methods to distinguish silkworm strains remain limited partially owing to the genetic similarity caused by the long history of domestication. By comparing publicly available complete mitochondrial genome sequences of five endemic strains and 34 stock silkworm strains analyzed in a previous study, we detected 15 single nucleotide polymorphisms (SNPs), which distinguished the following three endemic strains: Sun7ho (SN7), Sandongsammyeon (SDS), and Sammyeonhonghoeback (SMH). To distinguish each SN7 and SDS, the PCR-restriction fragment length polymorphism method was employed using Acu I and Hpa I restriction enzymes. Additionally, the tetra-primer amplification refractory mutation system PCR method was used to distinguish SN7, SDS, and SMH.

Key words: Silkworm, Mitochondrial genome, Single nucleotide polymorphism, Molecular identification

P185

Improvement of virus-inducible transient expression system using an additional promoter

Hyun Soo Kim, Cheol June Choi and Soo Dong Woo
Department of Agricultural Biology, College of Agriculture, Life & Environment Science, Chungbuk National University, Cheougju 28644, Korea

A technique for expressing a foreign protein using a baculovirus expression vector system has been widely used. Existing methods take a lot of time and money to produce a recombinant virus, so it is difficult to check whether the target protein could be expressed. Recently, virus-inducible transient expression systems have been developed for the rapid production of target proteins. However, the expression level of this system is limited. In this study, it was attempted to increase the expression level by using an additional auxiliary promoter to the previously reported vector. As a result, the effect of increasing the expression level was observed.

Key words: Baculovirus, BEVS, Virus-inducible transient expression

P186

Monitoring of termination over-wintering in honey bee (*Apis mellifera*) using digital sensors

Bo-Sun Park, Gyeongmoon kim, Ju-gyeing Kim, Dongwon Kim, Yong-soo Choi and Eun-Jun Kang
Department of Agricultural Biology, National institute of Agricultural Sciences

서양종 꿀벌의 월동 종료 시기를 관찰하기 위하여 벌통 내부에 온도 센서를 부착하여 2020년 8월부터 2021년 4월까지 벌통 내부의 온도를 관찰하였다. 벌통 내 온도 센서는 꿀벌 소비의 가장자리부터 안쪽까지 총 9개의 센서를 부착하여 관찰한 결과, 외부 온도의 변화에도 불구하고 벌통의 가운데 부분에 위치한 온도 센서에서는 온도가 31도 이상으로 유지가 되는 것을 확인하였다. 이를 통하여 꿀벌의 활동을 관찰하기 위해서는 벌통의 가운데 지점에 모니터링 해야 한다는 결론을 얻었다. 벌통의 가운데 지점의 온도 센서를 모니터링 한 결과, 벌통 내부의 온도는 20년 10월 말부터 변화하기 시작하여, 21년 2월 3일(음력 12월 22일, 입춘) 경에는 6℃까지 떨어지는 것을 확인하였다. 떨어진 온도는 2월 7일(음력 12월 26일)부터 증가하기 시작하여, 2월 9일(음력 12월 28일)이 되면서 30℃까지 오르게 되고 이후 온도가 유지되는 것을 확인하였다. 꿀벌 봉군 내 온도가 30℃가 되었다는 것은 꿀벌의 활동을 의미한다는 것을 알 수 있었으며, 본 실험을 통하여 꿀벌 봉군의 내부 온도 변화 측정으로 꿀벌의 활동 시기 및 월동기 확인이 가능한 것을 확인하였다.

검색어: 스마트양봉, 양봉꿀벌, 월동, 온도센서

P187

Development of a method to determine the strain and age of silkworms used in the production of HongJam

Phoung Nguyen[1], A-Young Kim[2], Hee-Jeong Choi[3] and Young Ho Koh[1,2]
[1]Ilsong institute of Life Science, Hallym University, Seoul.
[2]Department of Biomedical Gerontology, Hallym University Graduate School, Chooncheon, Gangwon-do.
[3]Mass-spectrometry Laboratory, Seoul Nation University NICEM, Seoul Korea

Hongjam is a natural health-promoting food made from mature silkworms and has various health-promoting effects. In order to manufacture the best Hongjam, it is necessary to use the mature silkworms in the previous stage of making a cocoon in which the intestines are degenerated and the silk glands are enlarged. Therefore, the quality of Hongjam is determined by whether or not the silkworms used for manufacturing has been mature silkworms. In this study, a method was developed to quickly check the strains and age of silkworms in the field using the color of the produced Hongjam powder. (RDA Grant No. PJ015659)

Key words; Mature silkworm, HongJam, powder, quality control

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Egg characterization and optimal hatching conditions of *Zophobas atratus* (Coleoptera: Tenebrionidae)

Sun Young Kim, Kyu-Won Kwak, Hyun-Jin Ko, Kyeong Yong Lee, Jeong-Hun Song and Hyung Joo Yoon*
Department of Agricultural Biology, National Institute of Agricultural Sciences, RDA

We investigated the hatching characteristics of *Z. atratus* eggs under varying conditions to optimize artificial rearing conditions. In general, the average egg weight, width, and length decreased by 42.3%, 3.7%, and 10.1%, respectively, on the 6th day post-oviposition. We varied either temperature, photoperiod, illuminance, or humidity, while the other conditions remained constant. Of the four experimental temperatures —25°C, 27°C, 30°C, and 33°C–30°C was associated with the highest hatching rate (91.0%) during days 5–7. Although other experimental conditions did not have a significant effect on hatchability, we were able to elucidate the ideal conditions for improved hatchability. For photoperiod, hatchability was the highest (84%) at 12L/12D, followed by 81.0% at 15L/9D, and 70% at 9L/15D. Among the illuminance conditions tested—600, 1800, and 3000 lx—hatchability was the highest at 1800 lx (82.3% on days 4–6). Thus, the ideal conditions for maximum hatchability were 30°C, 12L/12D, 65% RH, and 1800 lx. Under these combined conditions, the hatching rate significantly increased by 93.6%, and the hatching time was reduced by two days.

Key words: *Zophobas atratus*, egg characteristics, hatchability, artificial hatching conditions

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The artificial hatching conditions of *Locusta migratoria* (Orthoptera: Acrididae) eggs for the optimum hatchability

Sun Young Kim, Kyu-Won Kwak, Kyeong Yong Lee, Yong-Soon Kim and Hyung Joo Yoon*
Department of Agricultural Biology, National Institute of Agricultural Sciences, RDA

Locusta migratoria is potential as alternative foods and animal feed additives recently in South Korea and already registered in EU. We investigated the optimal conditions to improve hatchability of *L. migratoria* eggs under varying hatching conditions for improved artificial rearing. We varied either temperature, photoperiod, illuminance, or relative humidity, while the other conditions remained constant. On the conditions of hatchability, the temperature level of 30℃ among four different treatments of 25℃, 27℃, 30℃, and 33℃, showed the highest total hatching rate of 59% during days 8–12. For photoperiod, hatchability was the highest (81.2%) at 9L/15D, followed by 80.0 % at 12L/12D, and 72.6% at 15L/9D. Under illuminance conditions of 600, 1,800, and 3,500 lux, 3,500 lux displayed the highest total hatching rate of 76.1% at days 7–11 after oviposition. In short, the most effective conditions for hatchability were 33°C, 9L/15D, 65% RH, 3,500 lux. Under these conditions, the hatching rate increased significantly to 98.8%. Application of these conditions will contribute to improve hatchability, which will be necessary for industrialization of *L. migratoria*.

Key words: edible insect rearing, hatchability, hatching conditions, *Locusta migratoria*

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Developmental characteristics of *Zophobas atratus* (Coleoptera: Tenebrionidae) according to four types of artificial diet

Sun Young Kim, Kyu-Won Kwak, Kyeong Yong Lee, Hyun-Jin Ko and Hyung Joo Yoon*
Department of Agricultural Biology, National Institute of Agricultural Sciences, RDA

아메리카왕거저리 인공사료 종류에 따른 발육 특성을 조사하기 위하여, 밀기울을 대조로 하여 WF2, WF6, WFG1, WFG2 등 4종의 인공사료에 대한 발육 특성을 조사하였다. 4종 인공사료의 1-10령까지 발육 기간은 WF6이 53.4±7.5일, WF2 53.9±7.4일로 대조군인 밀기울(53.1±5.0일)보다 0.3-0.8일이 길었다. 반면에 인삼잎 가루가 첨가된 WFG1(58.3±7.0일), WFG2(55.9±6.2일)은 대조보다 2.8-5.2일 발육 기간이 길었다. 체중의 경우, 10령 기준으로 4종의 인공사료 WF2(58.7±43.4 mg), WF6(74.9±57.1 mg), WFG1(72.9±65.4 mg), WFG2 (46.6±20.8 mg)가 대조군(26.1±12.3 mg)보다 1.8-2.9배 높은 체중 증가 양상을 나타냈다. 4종의 인공사료 간의 비교 결과, 체중은 WF6(대조 대비 2.9배 증), WFG1(2.8배↑), WF2(2.3배↑), WFG2(1.8배↑) 순이었다. 12령까지 폐사율은 대조군과 WF2은 10%인데 반하여 WF6 38%, WFG1 55%, WFG2가 53%로 대조군 대비 28-45%나 높았다. 결과적으로 증체율, 발육기간, 폐사율을 고려했을 때 아메리카왕거저리의 인공사료는 WF2가 적합한 것으로 판단된다.

검색어: 아메리카왕거저리, 유충, 발육 특성, 인공사료

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Developmental characteristics affecting the maximum weight of *Protaetia brevitarsis seulensis* larvae

Sang-Min Ji, Wontae Kim, Sunyoung Kim and Jeong-Hun Song
Department of Agricultural Biology, National Institute of Agricultural Sciences

Many insect farms in Korea are rearing *P. brevitarsis seulensis* as an edible insect. However, the insect quality of each farm is not constant. In order to equalize the quality, it is necessary to supply a seed-insect species through selective breeding. We investigated characteristics that can be used for selective breeding by analyzing the relationships between each developmental characteristic. After conducting a growth investigation of larvae (N=180) in 11 regions, the relationships between each characteristic were analyzed through cluster analysis, one-way ANOVA, and regression analysis. The head width of each instar affects the initial weight of each instar and the initial weight of the next instar ($p<0.05$), but the development period and maximum weight of larva are not affected by the head width ($p>0.05$). The initial weights of 2nd and 3rd instars are affected by egg period ($p<0.05$). In order to increase the maximum weight of larva, it is predicted that egg period and 2nd instar period should be short, initial weights of 2nd and 3rd instars should be heavy. Additional verification of selective breeding is needed based on these results from the larvae of the *P. brevitarsis seulensis.*

Key words: *Protaetia brevitarsis seulensis* , develpmental charatreristics, maxumum weight

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Stress-reducing effects of healing program using *Bombyx mori* (Linnaeus)

Mi-Seon Song, So-Yun Kim, Jeong-Hun Song, Wontae Kim and Sangmin Ji
Department of Agricultural Biology, National Institute of Agricultural Sciences

최근 정서곤충을 이용한 치유프로그램의 효과가 보고되고 있지만, 프로그램에 이용된 곤충은 왕귀뚜라미와 호랑나비 등 일부 종에 불과하다. 본 연구에서는 '누에나방'을 이용한 치유프로그램을 개발하여 효과를 검증하고자 했다. 누에는 애완곤충 종 선발 평가지표에 의해 우선대상종으로 선발된 종으로 곤충 이미지에 대한 선호도와 인지도가 높아 곤충교감활동을 구성하기에 적합했다. 프로그램은 직접 돌보는 과정에서 누에의 한살이를 관찰하며 뽕잎 주기, 만져보기 등의 활동을 통해 곤충과의 상호작용을 극대화하고자 하였다. 또한, 문학과 미술, 놀이활동 등도 연계시켜 총 4회차로 구성하였다. 현장적용 및 데이터 수집은 전주시와 고창군 소재 지역아동센터를 이용하는 아동 43명을 대상으로 실시되었다. 분석 결과, 치유프로그램 적용 후 타액을 이용한 스트레스 수치는 20.23→15.65(KIU/L)으로 감소하였고, 곤충에 대한 선호도는 3.32→3.87점으로 증가하였다($p<0.05$). 현재 누에는 주로 식용과 산업화 소재로 이용되고 있지만, 본 연구를 통해 정서곤충으로 치유농업에서도 활용할 수 있다는 것을 구명한데 의의가 있다.

검색어: 정서곤충, 누에나방, 치유프로그램, 스트레스 감소

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Requirements and difficulties for the management of healing programs using insects

So-Yun Kim, Jeong-Hun Song, Wontae Kim and Sangmin Ji
Department of Agricultural Biology, National Institute of Agricultural Sciences

치유에 대한 국민적 관심 및 치유농업법의 시행과 더불어 곤충체험농가에서도 정서곤충을 이용한 치유프로그램 운영에 대한 요구가 증가하고 있다. 최근 농촌진흥청 시범사업/현장 실증이 이루어졌거나, 정서곤충 사육법에 대한 기술이전이 이루어진 농가, 현재 곤충체험프로그램을 운영하는 농가를 중심으로 향후 곤충치유프로그램 운영을 희망하는 13개 농가에 대한 설문조사 및 인터뷰를 2021년 10월 실시하였다. 그 결과 정서곤충으로 이용을 희망하는 종은 호랑나비(38%), 왕귀뚜라미(31%), 장수풍뎅이(21%), 누에(7%), 방울벌레(3%) 등이었다. 모든 농가는 전문적인 사육공간과 체험장 및 주차시설을 보유하고 있었으며, 1회 수용할 수 있는 인원은 100명 이상(2개소), 50-70명(2개소), 30명 이하(7개소)의 규모였다. 예상되는 애로사항은 치유효과의 측정방법(3.39점), 치유적인 요소와의 연계(2.92점), 치유에 대한 자료수집이나 내용구성의 어려움(2.62점) 등의 순으로 나타났다. 반면 대상이 되는 곤충의 구입 방법(2.15점), 사육법(2.00점) 등에 대한 어려움은 전반적으로 낮은 편이었다. 따라서 곤충치유를 목적으로 하는 농가를 육성하고 확산시키기 위해서는 곤충과 치유프로그램을 연계할 수 있도록 전문적인 교육이 필요할 것으로 보인다.

검색어: 치유농업, 정서곤충, 곤충치유프로그램, 요구사항, 애로사항

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Results of consumer awareness survey on insect industry

Wontae Kim, Jeong-Hun Song, Sangmin Ji, Sun Young Kim and Gyu-Dong Chang
Department of Agricultural Biology, National Institute of Agricultural Sciences

국내 곤충산업은 2010년 「곤충산업법」이 제정된 후 지난 10년 동안 연평균 11.5%씩 빠르게 성장하고 있고, 2030년에는 시장 규모가 6,309 억원 정도로 성장할 것으로 예상된다. 하지만 이러한 곤충산업의 잠재력에도 불구하고, 아직까지 산업으로서의 인식이 부족한 상황으로 소비자의 인식조사를 통해 현실을 파악하고, 향후 곤충산업 규모 확대, 연구방향 설정 및 곤충농가 경영전략 수립에 도움을 주고자 한다. 본 연구는 20대 이상 남녀 300명을 대상으로 곤충산업에 대한 인지도와 만족도를 인터넷으로 조사하였다. 그 결과, 곤충산업에 대한 인지도는 97%가 들어본 적 있다고 답하였고, 전반적 만족도 또한 92.7%가 만족하는 것으로 답하였다. 식용곤충에 대한 물음에는 '영양분이 풍부할 것 같다'라는 응답이 80.0%로 가장 많았고, 곤충식품에 대한 만족도는 67.7%가 만족하는 것으로 조사되었다. 애완용곤충에 대한 의견은 '교육적으로 효과가 있을 것 같다'라는 응답이 78.3%로 가장 많았고, 애완용곤충 사육에 대한 만족도도 78.4%로 높게 나타났다. 사료용곤충에 대한 물음에는 '영양분이 풍부할 것 같다'라는 답이 76.7%로 가장 많았고, 곤충을 활용한 동물사료에 대한 만족도는 81.6%로 조사되었다. 소비자의 인지도와 만족도는 높은 편이나, 여전히 곤충농가에서는 판매에 애로를 호소하고 있어, 민-관-학 합동으로 전략적인 정책수립과 곤충산업에 대한 홍보 강화가 필요해 보인다.

검색어: 곤충산업, 식용곤충, 애완용곤충, 사료용곤충

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User manual development of a healing program using *Papilio xuthus* Linnaeus

Hyunmyung Choi, So-Yun Kim, Jeong-Hun Song, Wontae Kim and Sangmin Ji
Department of Agricultural Biology, National Institute of Agricultural Sciences

호랑나비를 이용한 '호랑나비와 함께 날자!' 치유프로그램은 2019년과 2020년에 아동 191명과 노인 16명을 대상으로 현장에 적용하고 그 치유효과를 구명한 바 있다. 정서곤충을 이용한 치유프로그램은 곤충에게 먹이를 주고 돌보는 활동이 가장 핵심이며, 개인이 이 과정에서 얼마나 몰입하고 상호작용을 잘 이루어내느냐에 따라 치유효과는 달라질 수 있다. 따라서 이를 효율적으로 잘 수행해내기 위한 돌보기 매뉴얼을 개발하였다. 매뉴얼의 서두는 호랑나비의 성장 과정에 따른 생태적 특성을 간략하게 소개하여 이용자들의 호랑나비에 대한 이해도를 높이도록 했다. 본문에는 호랑나비의 먹이 식물인 운향과 식물에 대한 설명과 돌보기용으로 적합한 '루(*Ruta graveolens* L.)' 식물의 관리방법을 수록했다. 그리고 호랑나비의 각 사육 단계마다 관찰할 수 있는 특징들을 첨부하여 이용자가 다양한 정서적 교감을 느낄 수 있도록 유도하였다. 특히, 이용자가 호랑나비를 돌보면서 의문점을 가질 만한 점들을 상황으로 설정하여 사진 자료와 설명을 통해 해결 방법을 제시하여 돌보기 활동에 어려움이 없도록 하였다. 이를 통해 곤충치유프로그램을 처음 접하는 이용자들도 쉽게 접근할 수 있으며, 긍정적 치유효과를 높이는데 도움이 될 것으로 기대한다.

검색어: 정서곤충, 호랑나비, 돌보기 매뉴얼

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Selection of a commercially useful mealworm strain of *Tenebrio molitor* Linnaeus (Coleoptera: Tenebrionidae)

Jeong-Hun Song, Gyu-Dong Chang, Sangmin Ji, So-Yun Kim and Wontae Kim
Department of Agricultural Biology, National Institute of Agricultural Sciences

Alternative proteins based on yellow mealworms (*Tenebrio molitor* Linnaeus) as food and feed are an active area of research. To select the superior strain of *T. molitor*, we compared the developmental characteristics and fecundity of six strains (G101–G106). Larval survival, larval/pupal/adult weight, development time and fecundity were monitored for two consecutive generations. Among them, three items were determined as selection criteria: 1) larval duration from egg to pupa and 2) larval weight on shipping point (at 10 week, until the first pupation was observed) as cost-efficiency, and 3) the number of eggs as fecundity. The results showed that the strain G103 have significantly higher larval weight on shipping point and lower larval duration than other strains (G101–G102, G104–G106). The number of eggs in G103 was higher than other strains, but not statistically supported. In conclusion, we suggest G103 as a candidate strain for seedinsect yellow mealworm.

Key words: *Tenebrio molitor*, yellow mealworm, seedinsect selection

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Changes in silkworm antioxidant activity due to injection of foreign substances

Jong Woo Park and Chang Hoon Lee
Department of Agricultural Biology, Rural Development Administration

Silkworm has recently been attracting attention as a health functional food as various functionalities such as antioxidant activity, liver function improvement and dementia prevention are known. Most of the antioxidant functions of silkworms have been found to be derived from the host plant, mulberry leaf. However, the antioxidant activity was also high in silkworms of 5th instar 7 days of excretion of mulberry leaves. Therefore, if the antioxidant effect of silkworm itself can be enhanced, the economic value is expected to be higher. In this study, in order to determine whether there is a difference in the antioxidant efficacy of silkworms by supplying an antioxidant enhancement inducer to silkworms, antioxidant enhancement induction candidates were selected and injected into silkworms between the 5th instar 4-5 days, and silkworm extracts were prepared for antioxidant activity. was analyzed. As a result, it was confirmed that the antioxidant activity was increased by about 10% by the injection of several inducers such as vitamins and laminarin. However, in order to use this technology, it is judged that additional research on details for optimization, such as the appropriate concentration and method of supplying the inducer is necessary.

Key words: Mitochondrial genome, *Bombyx mori*, Domesticated silkworm, Phylogeny

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Visualizing the nutritional performance landscapes for the black soldier fly, *Hermetia illucens* (Diptera: Stratiomyidae)

Taehwan Jang, Du Am Cheon and Kwang Pum Lee
Department of Agriculture Biotechnology, Seoul National University

The black soldier fly (BSF), *Hermetia illucens* (Diptera: Stratiomyidae), has become one of the most economically important insects that can be a sustainable replacement for traditional feed. Despite its emerging importance, studies examining the nutritional requirement of BSF have been scarce. Here we used nutritional geometry approach to determine the separate and combined effects of dietary protein and carbohydrate content on multiple life-history traits in BSF. BSF larvae were reared on one of 32 chemically defined diets that varied in protein-to-carbohydrate ratio (P:C=1:16, 1:8, 1:4, 1:2, 1:1, 2:1, 4:1, or 8:1) and in protein plus carbohydrate concentration (P+C=60, 120, 180, or 240 g/l). The nutritional optima were located at the P:C ratio of 1:1.7 for survivorship, 1:1.1 for development time, and 1:3.2 for body weight. Most importantly, the proxy measure of larval fitness peaked at the P:C ratio of 1:1.4. Our results highlight the importance of balanced composition of dietary protein and carbohydrate for optimizing BSF performance and have implications for enhancing the mass production of this beneficial species.

Key words: Carbohydrate, Insects as feed, Macronutrient, Nutritional geometry, Protein

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Economic effect and *Protaetia brevitarsis* (Coleoptera: Cetoniidae) production by fermented sawdust type

Ju Rak Lim, Sang-Ssik Lee, Eun-jin Lee, Jun-Hee Nam, Woong Kim, Chang-Hak Choi and Hee-Jun Kim
Sericulture and Entomology Experiment Station, Jeonbuk Agricultural Research & Extension Service

전북지역에서 많이 재배되는 베리류(뽕나무, 복분자, 블루베리) 전정가지를 톱밥으로 발효시켜 흰점박이꽃무지 먹이원으로 사용하고 생산량 및 경제적 효과를 분석하였다. 사육방법은 흰점박이꽃무지 표준 사육기술에 준하였고, 기존의 참나무발효톱밥을 이용한 사육방법과 비교하였다. 톱밥종류별 생산량은 참나무톱밥에 비해 22% 증가하였고, 사육기간은 30일정도 단축되었다. 또한 경제성을 분석한 결과 베리류톱밥 사용시 참나무톱밥 사용시에 비해 사료비가 22% 절감되고, 소득은 45.8%가 증가하였다. 또한, 톱밥종류별 흰점박이꽃부지 유충의 기능성 성분 함량을 분석한 결과 참나무발효톱밥에 비해 총폴리페놀과 플라보노이드 함량이 높았고, ABTS와 DPPH 함량은 비슷하였다.

검색어: 흰점박이꽃무지, 베리류발효톱밥, 참나무발효톱밥, 생산량, 경제성

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Chungcheong province honey plant planting model through regional climate and flowering characteristics analysis

Daegeun Oh, Yong soo Choi, Dongwon Kim, Su-bae Kim, Bo Sun Park, Kyung Mun Kim, Olga Frunze, Ju-gyeong Kim and Eun Jin Kang
Apiculture Division, Department of Agricultural biology, National Institute of Agricultural Science, RDA

전 세계적으로 발생하고 있는 기후변화는 밀원식물의 개화시기 변동, 꽃꿀 분비량 변화 등에 영향을 미쳐 양봉산물의 생산에 영향을 미치고 있다. 최근 국내 생산 벌꿀의 70%를 생산하는 아까시나무 개화기간의 이상기상 발생으로 인해 벌꿀 생산량이 감소하고 있으며, 전국 동시 개화현상으로 이동양봉의 효율이 감소하고 있다. 따라서 본 연구에서는 양봉산물 주년생산과 양봉농가의 봉군관리 비용 절감을 위해 충청지역의 기후와 식재 가능 여부, 개화기 등을 고려하여 충청지역의 밀원수 식재모델 개발을 수행하였다. 또한 양봉산물의 생산뿐만 아니라 꽃축제, 밀원수의 생산물 판매 등 상업적인 용도로 사용할 수 있는 밀원수를 선별하여 다양한 이익을 취할 수 있는 밀원수 식재 모델을 제시하고자 하였다.

검색어: 밀원수, 이상기후, 꿀벌, 식재모델, 양봉산물

P201

The feeding effect of decreasing the *Pseudomonas aeruginosa* using a biocontrol bacterium in mealworm

Ji Soo Kim, Hui Yeon Koo, Do Ik Kim, Hyeon Jin Kim, Yu Beom Lee, Sang A Oh and Jeong Hee Lee
Jeonnam Insect and Sericultural Research Institute, Jangseong, 57214, South Korea.

최근 곤충 장내에 존재하는 미생물과 숙주인 곤충의 생육관계가 활발히 연구되고 있다. 그중에서도 *Bacillus* 속 균주 대부분이 인·축 독성에 대한 안전성을 갖고 있으므로 *Bacillus amyloliquefaciens* KB3와 *Bacillus amyloliquefaciens* LM11 두가지 균주를 갈색거저리 먹이원인 밀기울에 30일 동안, 1%첨가비율로 혼합 급이하였다. 그 결과 녹농균에 대한 질병저감 효과는 *Bacillus amyloliquefaciens* LM11(1.3×10^{10}CFU/㎖, 분무건조)의 경우 대조구(밀기울 급이) 대비 22% 증가하였고 *Bacillus amyloliquefaciens* KB3(5.2×10^{10}CFU/㎖, 분무건조)의 경우 14%증가하였다. 갈색거저리 사육농가에서는 녹농균병에 대한 병징 파악이 어렵고 이병충의 관리가 소홀하여 대발생을 야기할 수 있으므로, 갈색거저리 발생 녹농균병 방제를 위한 안정적인 사육 환경조성 및 질병제어기술로 활용할 예정이다.

검색어: 갈색거저리, 녹농균, 질병저감, 방제균, 급이효과

P202

Physiological characteristics of silkworms raised with artificial feed

Seong Wan Kim, Jong-Woo Park, Sang Kug Kang, Nam Suk Kim and Kee Young Kim
Department of Agricultural Biology, National Academy of Agricultural Science, Rural Development Administration, Wanju Gun, Republic of Korea

누에는 곤충 중에서도 단식성 또는 협식성 곤충으로 널리 알려져 있으며 오랜 세월 동안 뽕잎만 먹고 살아왔다. 그러나, 1800년대 유럽에서 누에를 뽕잎에 의존하지 않고 사육하는 연구가 최초로 진행되었고, 우리나라는 1960년 누에의 영양 요구성 및 뽕의 엽질 문제를 해결하기 위해 누에인공사료에 대한 연구가 시작되었다. 이후 인공사료는 애누에 공동사육용으로 주로 사용되고 있으며, 전령 사육 및 고치 생산용으로는 아직 농가에 적용하기 어려운 실정이다. 본 연구에서는 전령 사육용 누에인공사료 개발을 위해 기존에 사용되고 있는 애누에 인공사료를 개선하였다. 그 결과, 기존 애누에 사육용 인공사료와는 달리 고치 생산 및 누에알 채종이 가능하였고. 사육 기간은 뽕잎 사육 대비 인공사료 사육이 1일 23시간 단축되었다. 그러나 뽕잎으로 사육된 누에 대비 인공사료로 사육된 누에의 고치와 유충 무게는 비교적 가벼웠다.

검색어: 누에, 인공사료, 장려품종, 대량사육 시스템

P203

Comparison of attraction effects of various types of fruit fly traps and lures

Jung Hoon Hwang and Yong-Bong Lee
Plant Quarantine Technology Center, Animal and Plant Quarantine Agency

과실파리는 농업적으로 중요한 해충으로 검역본부에서는 46종을 금지해충으로 지정하여 관리하고 있으며, 고위험 과실파리의 유입을 조기에 탐지하기 위하여 예찰을 실시하고 있다. 과실파리 예찰에는 주로 스테이너트랩과 액상형태의 유인제를 사용하고 있으나, 현재는 다양한 형태의 트랩과 유인제가 출시되어 활용이 가능하다. 본 연구에서는 4종의 트랩과 3가지 형태의 유인제를 대상으로 통계프로그램 R을 이용하여 유인효과를 분석하였다. 분석결과 평균의 차이는 있었으나, 통계적으로는 유의성 있는 결과는 아니었다. 다만, 1년의 연구자료로는 검증이 부족한 것으로 판단되어 추가적인 연구자료를 확보한 후 재분석이 필요할 것으로 판단된다.

검색어: 호박꽃과실파리, 트랩, 유인제, 효과검증, 통계프로그램 R

P204

A diagnostic loop-mediated isothermal amplification assay for the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

Jeong Sun Park[1], Keon Hee Lee[1], Min Jee Kim[1,2], Su Min Park[1], Deuk-Soo Choi[3], Kyeong-Yeoll Lee[4] and Iksoo Kim[1*]

[1]Department of Applied Biology, Chonnam National University
[2]Honam Regional Office, Animal and Plant Quarantine Agency
[3]Department of Plant Quarantine, Animal and Plant Quarantine Agency
[4]Department of Applied Biosciences, Kyungpook National University

검역 관리해충인 열대거세미나방(*Spodoptera frugiperda*)은 아프리카, 인도 및 중국 등으로 급속히 확산한 후 최근 국내에서도 발생이 확인되고 있다. 본 연구에서는 비례해오는 열대거세미나방의 신속한 진단을 위해 loop-mediated isothermal amplification (LAMP)법을 이용한 진단법을 개발하고자 하였다. 국내 발생하는 *Spodoptera*속 및 유사기주 종과 유입가능성이 높은 *Spodoptera*속 내 검역관리해충 등 총 13종의 비표적종을 포함하여 whole genome에 기반한 5개의 진단법을 개발하였다.

검색어: *Spodoptera frugiperda*, Fall armyworm, LAMP, Whole genome

P205

Use of supplementary tools for efficient microinjection of silkworm egg

Chan Young Jeong, Kee Young Kim and Jong Woo Park
Industrial Insect and Sericulture Division, National Institute of Agricultural Science, Republic of Korea

Silkworms are recently attracting attention as biological factories for the production of new bio materials. To produce special materials such as fluorescent silk and viral antigen proteins, silkworm transformation techniques are applied. It goes through a microinjection method in which foreign genes are inserted into eggs with embryos. Microinjection requires a process of arranging and fixing silkworm eggs. In this study, in order to increase the transformation efficiency, an egg liner (EL) and a glue drawer (GD) were designed and manufactured by 3D printing. As a result of using the manufactured tools and comparing the time required, the working time was reduced by about 18.6% when using two tools compared to when the tools were not used. Therefore, an egg liner and a glue drawer can be used to improve silkworm transformation efficiency and transform other industrial insects.

Key words: Silkworm egg, Microinjection, Supplementary tool, 3D printing

P206

Physicochemical properties of dried *Hermetia illucens* larvae blanched by various methods

Tae-Kyung Kim, Ji-Yoon Cha and Yun-Sang Choi
Research Group of Food Processing, Korea Food Reaserch Institute

With interst about substitution of conventional food or feed, insects has been reared as substitution and the most edible insects has been consumed after drying to increase their shelf-life. Before drying, pre-heat treatment such as blanching can inactivate enzymes which could induce undesirable changes. Various pre-heat processing were conducted in this study (water blanching, roasting, super-heated steam blanching). Drying speed, shear force, and rehydration ratio of super-heated steam (SHS) treatment were the highest. Although the highest polyunsaturated fatty acid composition was observed in non-blanched treatment, SHS treatment was followed and the lowest lipid oxidation value was observed in SHS treatment. In addition, the highest histidine amount also observed in SHS treatments. In conclusion, SHS not only can be used to improve efficiency of drying processing, but also can decrease lipid oxidation with good quality.

Key words: *Hermetia illucens*, blanching, roasting, superheated steam, drying

P207

Comparative study of lipases from entomopathogenic fungi

Hyun Ji Kim[1], Jae Young Choi[2], Sang Hee Kim[1], Dong Hwan Park[1], Minghui Wang[1], Ho Yeon Lee[1], Min Gu Park[2] and Yeon Ho Je[1,2]
[1]Department of Agricultural Biotechnology, Seoul National University, Seoul, Republic of Korea
[2]Research Institute for Agriculture and Life Sciences, Seoul National University, Seoul, Republic of Korea

Lipase which catalyzes the hydrolysis of triacylglycerol and/or esterification between glycerol and fatty acid is one of the enzymes attracting attention in the rapidly growing biological industry. Lipase derived from an entomopathogenic fungi, *Cordyceps militaris*, was found to act specifically at position 1,3 of triacylglycerol. In this study, characteristics of lipases isolated from entomopathogenic fungi were investigated and conditions for mass expression using the baculovirus expression system were established. Lipase genes of *Beauveria bassiana* JEF-351 strain (BBL351) and *C. militaris* (CML) were introduced into the genome of *Autographa californica* nucleopolyhedrovirus (AcMNPV) and recombinant lipases were expressed as non-secreted and secreted protein, respectively. In both BBL351 and CML, their enzyme activity was higher when they expressed as secreted protein form, demonstrating that post-translational modification such as glycosylation is crucial for their activity. In addition, the enzyme activity of BBL351 was higher than that of the CML, suggesting that the lipase derived from the *B. bassiana* JEF-351 strain could be useful as biocatalyst in the biotechnological applications.

Key words: Lipase, entomopathogenic fungi, *Beauveria bassiana*, *Cordyceps militaris*

P208

Current status of Arthropoda inspected through the Joint Inspection Center for Alien Species

A-Ram Jo, Do-Young Chae, Dong Eon Kim, Su-Hwan Kim and Hee Jo Lee*
Invasive Alien Species Team, National Institute of Ecology

환경부와 관세청, 국립생태원은 국내로 유입되는 외래생물 중 국내 생물다양성에 위해가 되는 생물을 통관단계부터 선제적으로 차단하기 위해 인천세관 내 외래생물 협업검사센터를 운영하고 있다. `20년 3월부터 `21년 12월까지 검사한 외래생물 총 1865종 중 절지동물(곤충류, 거미류, 가재류, 등각류)의 종 수는 37종(1.98%)이었다. 구체적으로 연구용으로 수입된 붉은불개미(생태계교란 생물, 20,000여 개체), 상업용으로 수입된 미국가재(생태계교란 생물, 21톤), 체코에서 밀반입된 거미류(63개체)가 포함되어 있다. 대부분 100개체 미만의 소개체 단위로 수입되었다. 살아있는 곤충류는 식물방역법상 수입이 관리되고 있지만 애완용, 상업용, 연구용 등 다양한 목적으로 절지동물에 대한 수입이 늘어남에 따라, 국내 도입 생물 목록 파악과 생물종에 대한 DB 구축, 자료 확보가 필요하다.

검색어: 외래생물, 협업검사센터, 절지동물, 붉은불개미

P209

Simplified crop loss analysis from alien pests for decision-making by plant quarantine policymakers in Korea: Case study I. Oriental Fruit Fly

Yoon-Jung Uhm and Ki-Jeong Hong*
Department of Plant Medicine, Sunchon National University, Suncheon, 57922, Korea

Figuring out the extent of damage caused by the invasion of alien pests is highly important as one of the decision-making tools for policymakers to manage invasive alien species in biosecurity. There are economic analysis studies on estimating the damage by applying various parameters and methodologies that have yielded worthy results. However, those studies often cover too many repercussions that cause decision-making to waver. Thus this study suggests Simplified Crop Loss Analysis (SCLA) that calculates direct financial loss for each damaged crop under the premise of "Simple is best." The formula for this is as follows. Financial Loss (FL) = Crop Production (CP) × Market Price (MP) × Infestation Rate (IR). In our first case study about the Oriental Fruit Fly (OFF, *Bactrocera dorsalis*), we assume this troublesome insect pest was introduced and established in Korea. As a result, the estimation of direct financial damage due to crop loss is 257.9 billion won based on the study of Kim et al. (2020) that forecasts OFF can establish in Seoguipo-si, Jeju island. We hope Simplified Crop Loss Analysis (SCLA) would leverage as an effective tool for policymakers to make quick and accurate decisions.

Key words: Oriental fruit fly, Plant quarantine policy, Decision-making, Crop damage, Financial loss

P210

The complete mitochondrial genome of *Cacopsylla burckhardti* (Hemiptera: Psylloidea: Psyllidae)

Euna Jo[1,2] and Geonho Cho[3*]

[1]Division of Biotechnology, College of Life Sciences and Biotechnology, Korea University, Seoul 02841, Korea
[2]Divistion of Life Sciences, Korea Polar Research Institute (KOPRI), Incheon 21990, Korea
[3]Department of Forest Resources, Sunchon National University, Suncheon 57922, Korea

Cacopsylla burckhardti Luo, Li, Ma & Cai, 2012 (Hemiptera: Psylloidea: Psyllidae) is a pear psyllid species distributed in the East Asia. The complete mitogenome of *C. burckhardti* is obtained in this study for the first time. The mitogenome of *C. burckhardti* is circular form and 14,798 bp long, which consists of 13 protein-coding genes, 22 tRNAs and 2 rRNAs. The base composition is 38.80% for A, 34.89% for T, 9.99% for G and 16.33 for C, with the higher A+T contents (73.69%). The phylogenetic analysis using 13 protein-coding genes shows that *C. burckhardti* is included with other *Cacopsylla* species and nested in the Psyllidae clade within the superfamily Psylloidea.

Key words: *Cacopsylla*, *burckhardti*, mitochondrial genome, phylogenetic analysis, pear psyllids, Hemiptera, Psyllidae

P211

Fluctuation of population density and insecticidal efficacy from the overwintered thrips under plastic house

Min Jeong Kwon, Yul Kyun Ahn, Kue Hyon Hong and Deok Ho Kwon
Department of Vegetable Crops, Korea National University of Agriculture and Fisheries, Korea

Density fluctuations of thrips were compared between cucumber seedlings and yellow sticky traps in a plastic house (120 m^2) located at Korea National University of Agriculture and Fisheries. After positioning three yellow sticky traps and nine cucumber seedlings, the daily occurrence densities of thrips was approximately 229 and 161 individuals, respectively. To establish the control strategy, we investigated the mortality rate, feeding area on cucumber leaf, and hatchability against 16 insecticides based on the leaf-dipping bioassay method. The overall mortality rate was generally low about 1.7 to 13.7%. On the other hand, the ingestion area of cucumber leaf discs was specifically low in the leaves treated with spinetoram, abamectin, emamectin benzoate, and fluxametamide. Moreover, when observing the hatchability on the 8th day of insecticide treatment, the hatchability was within 10% in spinetoram, abamectin, emamectin benzoate, catap hydrochloride, cyantranniliprol and fluxametamide. These results implicates that some of the insecticides might protect the cucumber leaf disc by inducing suppression of feeding and egg-layering of target pests.

Key words: Thrips, Population density, Insecticide