2022 Fall
International Conference of

KSAE

60th Anniversary

26(Wed)-28(Fri) October 2022

LAHAN SELECT Hotel, Gyeongju, Korea

Organized by (사)한국응용곤충학회 Korean Society of Applied Entomology

Sponsored by KOFST 농림축산검역본부 Animal and Plant Quarantine Agency 교육부 Ministry of Education

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본 사업은 기획재정부의 복권기금 및 과학기술정보통신부의 과학기술진흥기금으로 추진되어
사회적 가치 실현과 국가 과학기술 발전에 기여합니다.
This work was supported by the Korean Federation of Science and Technology Societies(KOFST)
Grant funded by the Korean government.

인사말

존경하는 회원 여러분, 그리고 바쁘신 일정 중에도 한국응용곤충학회 60주년이라는 뜻깊은 자리를 빛내주시기 위해 참석해 주신 내외빈 여러분,

안녕하십니까?

청명한 가을 하늘이 반겨주는 오늘, 천년의 역사를 품고 있는 이곳 경주에서,

한국응용곤충학회가 걸어온 60년의 발자취를 뒤돌아보고 새로운 도약을 준비하는 자리를 마련하였습니다. 이 자리는 학술적인 교류뿐만 아니라 축제의 자리이기도 하며, 또한 우리의 미래를 준비하는 자리이기도 합니다. 한국응용곤충학 역사의 한 페이지를 함께하는 여러분, 환영합니다.

우리나라 응용곤충학 발전의 기틀을 마련해주신 박규택 고문님을 비롯한 여러 원로 학자님, 직접 참석 하셨거나 또는 영상으로 축하를 보내주신 한국곤충학회장님, 한국병리학회장님, 한국방역협회장님을 비롯한 여러 관련 학회장님, 농촌진흥청장님, 산림청장님, 동식물검역본부장님, 국립생태원장님, 국립생물자원관장님 등을 비롯한 각 기관장님, 진심으로 감사의 인사를 올립니다. 꾸준히 학회발전에 이바지해 주시고 함께 성장하고 있는 많은 작물보호 회사, CRO 회사, 과학상사 등 모든 관련 업계 여러분들의 헌신에 깊이 감사 드립니다. 그리고 특히 영상으로 축하 메시지를 보내주신 ESA 회장이신 Jessica Ware 박사님, 등 여러 분야 국외 석학들의 축하에 감사드립니다.

1962년 한국식물보호학회로 시작한 우리 학회는 올해로 60주년을 맞이하게 되었습니다. 60년이라는 시간 동안 빠르게 변화는 시대 흐름에 발맞추어 우리나라의 곤충학, 선충학, 농약학 등 다양한 학문발전의 원동력과 추진체가 되었고, 인재 양성은 물론 한국 농산업 미래를 준비하는 연구공동체로 자리매김하였습니다. 이는 원로 학자님을 비롯하여 정부, 학계 및 관련 업계가 끊임없이 함께 노력한 결과라 생각합니다. 또한 미래를 준비하고 있는 젊고 패기 넘치는 여러분들이 있기에 가능한 일이었습니다. 이를 증명하듯, 이번 학술행사에는 430여 편의 학회 최대 숫자의 초록이 접수되었고, 약 600여 명의 회원이 참석하였습니다. 기후변화, 식량안보의 문제 등 우리 앞에서 앞으로 함께 머리를 맞대고 풀어나가야 할 숙제가 많이 있습니다만, 여러분들의 계시기에 우리 한국응용곤충학의 밝은 미래를 믿어 의심치 않습니다.

그동안 다년간 60주년 기념행사를 준비해주신 전임 이시혁 회장님, 그리고 이경열 준비위원장님, 임언택 학술위원장님, 분야별 기념심포지엄 좌장님을 비롯한 많은 회원분의 노력과 헌신에 다시 한번 깊은 감사를 드립니다.

아울러 이 자리를 빌려 특별히 감사드리고 싶은 분들이 있습니다. 우리 학회의 상징인 학술지 업무에 오랜 기간 수고하시는 한국응용곤충학회지의 김동순 수석부회장님, 현 박정준 위원장님 그리고 5년 이상 오랜 기간 영문지, JAPE 편집장으로 수고하시는 조기종 위원장님께 진심으로 감사의 인사를 드립니다. 지면 관계상 일일이 거명은 하지 않았으나 많은 분이 오늘 행사를 위해 수고를 아끼지 않았습니다. 이 모든 분께 다시 한번 감사드립니다.

오늘 행사의 주인공은 우리 모두입니다. 준비한 기념행사, 심포지엄 등 다양한 프로그램을 마음껏 즐기시고, 활발한 교류의 장이 되길 간절히 바랍니다. 아울러 항상 건강하시고 회원 여러분 가정에 행운이 가득하시길 기원합니다. 감사합니다.

2022년 10월 26일

사단법인 한국응용곤충학회

33대 회장 **박 종 균**

Program

■ 2022 Fall International Conference of Korean Society of Applied Entomology - 60th Anniversary ■

26 October (Wednesday)

Time	Section	Room
12:00~	Registration	Desk
	Member Symposia	
13:00~15:40	Recent Trends on Quarantine Fumigation Research Jongho Lee · Jun-Ran Kim (Animal and Plant Quarantine Agency)	Convention A (B1)
	Online Insect Community (Gonchoong-nara Sikmool-nara) Soo Jeong Ahn (Agricultural Corporation ERANG Co., Ltd.)	Convention B (B1)
	Insect Chemical Ecology in Korea (6th): Past, Present and Future Perspective Junheon Kim (National Institute of Forest Science)	Convention C (B1)
	Oral Sessions Ⅰ (Competition)	
13:00~15:40	All topics by Postgraduates	Capella Hall (B1)
	High School Student Presentation (Competition)	
14:30 ~15:40	Topics on Insect Study	Deneb (B1) (ZOOM)
15:40~16:00	Break	
16:00~17:30	Celebration of 60th Anniversary (Introduction, Congratulations, Reports, Awards of Dongoh Farming Foundation and High School Student Competition)	Convention A+B+C (B1)
17:30~17:40	Photography for all Together	
17:40~20:00	Celebration of 60th Anniversary: Sand Art Performance Welcome Reception (Buffet Dinner Provided)	Convention A+B+C (B1)
	Small Group Meetings Ⅰ	
20:00~21:30	Biological Control in Practice Duck-Oung Jung (Kyungpook National University)	Capella Hall (B1)
	Editorial Board Meeting : Publishing Policies, Research Ethics & Education, etc. Kijong Cho (Korea University) Jung-Joon Park (Gyeongsang National University)	Deneb (B1)

27 October (Thursday)

Time	Section	Room
Oral Sessions Ⅱ (Competition)		
09:00~11:20	Group 1 : Taxonomy by Graduates	Convention A (B1)
	Group 2 : Physiology/Applied Entomology by Graduates	Convention B (B1)
	Group 3 : Ecology/Pest Control by Graduates Ⅰ	Convention C (B1)
	Group 4 : Ecology/Pest Control by Graduates Ⅱ	Capella Hall (B1)
11:20~11:30	Break	
Award of KSAE and Lecture		
11:30~12:00	Development of mass production technology of the bumblebee as a pollinator and standardization of field application technology for fruit and vegetables Hyung Joo Yoon (National Academy of Agricultural Science)	Convention A (B1)
12:00~13:30	Lunch (Provided)	Polaris Hall (B2)
60th Anniversary Symposia Ⅰ		
13:30~16:00	Last 60 Years and Next 60 Years in Insect Physiology Jum Rae Cho · Youngjin Park (Animal and Plant Quarantine Agency)	Convention A (B1)
	Development and Future of Insect Systematics in Korea Sora Kim (Jeonbuk National University)	Convention B (B1)
	Linking Together Ecology of Insects Doo-Hyung Lee (Gachon University)	Convention C (B1)
	Trends in the Current Insect Pest Management Paradigm Juil Kim (Kangwon National University)	Capella Hall (B1)
16:00~16:10	Break	
16:10~17:10	Poster Sessions (Competition/Non-competition)	Vega Hall (B1)
General Meeting of KSAE and Events to Celebrate 60th Anniversary		
17:10~17:30	Presidential Address and Business Reports	Convention A+B+C (B1)
17:30~18:30	Concert by a Guest Singer (Suh Youngeun) and KSAE Members	
18:30~20:30	Welcome Reception (Buffet Dinner Provided)	
Small Group Meetings Ⅱ		
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28 October (Friday)

Time	Section	Room
	60th Anniversary Symposia II	
09:00~11:30	Insect Pathology for Pest Management Jae Su Kim (Jeonbuk National University)	Convention A (B1)
	New Frontiers in Tick Research Donghun Kim (Kyungpook National University)	Convention B (B1)
	Insect Molecular Biology and Its Application Young Ho Kim (Kyungpook National University)	Convention C (B1)
	Research Status and Future Prospects of Industrial Insects Wontae Kim (National Institute of Agricultural Sciences)	Capella Hall (B1)
11:30~12:30	Closing Ceremony (Awards of Competition and Raffle Tickets, Presidential Address)	Convention A (B1)

JOB CAFE 운영안내	
기관, 기업체와 취업을 희망하는 회원들과의 만남	
장소	라한셀렉트호텔 경주 컨벤션 홀 로비
일시	2022년 10월 26일 11시 ~ 10월 28일 11시

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Special Lecture

10. 27. Thu | Convention A (B1) | **Organizer :** Dong-soon Kim (Jeju National University)

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Symposium - Member Symposia

SI. Recent Trends on Quarantine Fumigation Research

10. 26. Wed | Convention A (B1) | **Organizer :** Jongho Lee (Animal and Plant Quarantine Agency), Jun-Ran Kim (Animal and Plant Quarantine Agency)

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Symposium - 60th Anniversary Symposia I

S4. Last 60 Years and Next 60 Years in Insect Physiology

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Symposium - 60th Anniversary Symposia II

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10. 26. Wed | Deneb (B1) | **Organizer :** Kijong Cho (Korea University), Jung-Joon Park (Gyeongsang National University)

Academic Committee Meeting

10. 27. Thu | Capella Hall (B1) | **Organizer :** Un Taek Lim (Andong National University)

Special Lecture

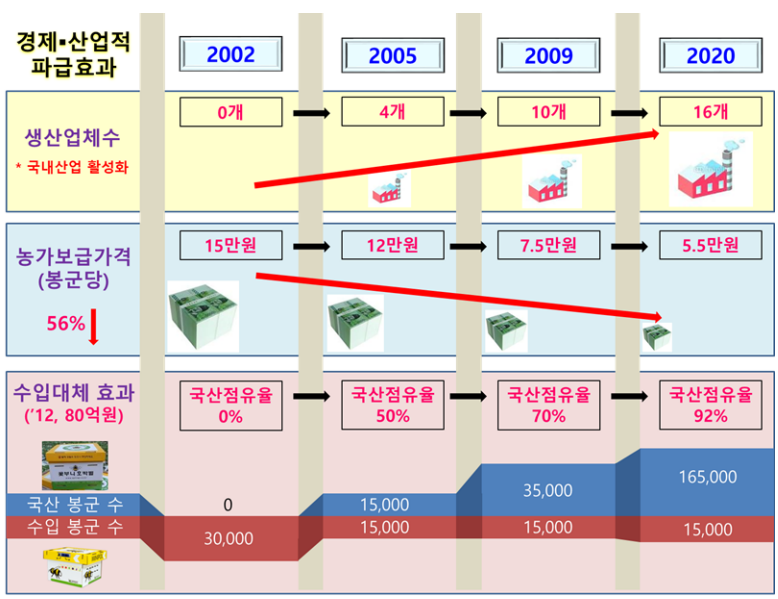
KSAE

60th Anniversary

Development of mass production technology of the bumblebee as a pollinator and standardization of field application technology for fruit and vegetables

Hyung Joo Yoon
Department of Agricultural Biology, National Academy of Agricultural Science, Wanju 55365, Republic of Korea

사계절 과채류를 요구하는 소비자들의 니즈(needs)에 따라 시설재배의 증가 함께 화분매개곤충의 필요성이 대두되었다. 고품질의 과채류 생산 및 노동력 절감을 위해서는 무엇보다도 화분매개곤충 뒤영벌의 대량생산 기술 개발이 급선무였다. 뒤영벌의 대량생산을 위해 고안된 한 방법으로 온돌 방식을 응용하여 뒤영벌의 산란율 및 봉군 형성율을 크게 향상시킨 효율적이고 안정적인 대량 생산 시스템을 개발하였다. 이를 통해 2000년대 초까지 전량 수입에 의존하던 화분매개곤충 뒤영벌의 대량생산 및 현장보급 기술이 우리나라 국립농업과학원 농업생물부에서 개발된 것이다. 현재 16 개의 국내 업체가 생산 보급함으로써 수백억 원의 수입대체 효과를 거두고 있다. 아울러 과채류에 화분매개곤충의 효과적인 현장 적용을 위해 현장 적용 기술 표준화와 함께 현장 지도 교육을 꾸준히 실시하였다.



삼십년 가까이 화분매개곤충 관련 연구를 수행하였습니다. 최근 10년간의 업적에 기초할 때, 114 건의 논문과 30 건의 저서뿐만 아니라 69 건의 특허와 371 건의 유·무상 기술이전을 토대로 불모지였던 국내 화분매개곤충 분야와 산업을 개척할 수 있었던 것은 국립농업과학원 농업생물부의 지원과 농촌진흥청 지정 전문연구실(화분매개곤충연구실) 실원 여러분의 땀과 노력이 있었기에 가능하였습니다. 함께 해주셔서 정말 고맙습니다. 그리고 공식적인 연구자의 마지막을 우리 학회 회원 여러분이 주시는 '응용곤충학상'으로 마무리 할 수 있게 되어 더 없는 영광이고 고마움입니다. 한국응용곤충학회의 새로운 60년을 응원합니다.

검색어: 뒤영벌, 화분매개, 대량사육, 현장적용, 적용 기술 표준화

Symposium

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KSAE

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S1-1

Recent methyl bromide alternative researches for plant quarantine – an update

Bong-su Kim, Young-mi Moon and Jun-ran Kim*
Animal and Plant Quarantine Agency, Republic of Korea

Since several alternative treatment methods were newly developed, methyl bromide(MB) usage for plant quarantine in Korea is decreasing recently. Ethyl formate and phosphine are most successful and widely used MB alternative fumigants for plant quarantine. Ethyl formate is newly developed as a methyl bromide alternative fumigant for fresh commodity, and shows reliable efficacy with low toxicity. Phosphine also is a potential MB alternative, and cylinderized phosphine has been commercialized to reduce phytotoxicity on fruits and vegetables. Concurrent treatment of ethyl formate and phosphine shows enhanced efficacy with shorter fumigation time. Microwave, hot water immersion, vapor heat treatment, cold treatment and irradiation are commonly used physical treatment methods for plant quarantine. Recent researches indicate that combined treatment of physical treatment with fumigant can improve efficacy on pests.

Key words: Quarantine, Chemical treatment, Physical treatment, Combined treatment

S1-2

Ethyl formate fumigation for postharvest disinfestation of tropical commodities

Dong H. Cha[1], Bong-su Kim[2], Taehyung Kwon[1,3] Min-Goo Park[4] and Byung Ho Lee[3]
[1]USDA-ARS, Pacific Basin Agricultural Research Center, Hilo, HI, USA
[2]Animal and Plant Quarantine Agency, Republic of Korea
[3]Kyungpook National University, Republic of Korea
[4]Jeonbuk National University, Republic of Korea

Tropical fruits and ornamentals, such as pineapple, citrus, banana, and orchids, are among the most traded agricultural commodities around the world. As climate change and global warming progress, there is a greater risk for tropical invasive pests overwintering in temperate region and getting established once they invade a new area. To address this issue, USDA-ARS in Hawaii has been developing ethyl formate-based fumigation treatments for various tropical horticultural and ornamental commodities. This talk reports on cooperative efforts between USDA-ARS, tropical commodity industry, and foreign counterparts (e.g. APQA) to address pest-related barriers to export and import. We present research progress toward the control of various tropical pests including mealybugs, thrips, fire ants, and fruit flies. Results are discussed based on technical efficacy, as well as, logistical and operational considerations.

Key words: ethyl formate, fumigation, tropical commodity, methyl bromide alternative

S1-3

Synergistic effect of cold treatment combined with two fumigants against *Drosophila suzukii* (Diptera: Drosophilidae)

Hyun Kyung Kim, Jong-Chan Jeon, Seung-Ju Seok, Hyun-Na Koo and Gil-Hah Kim
Department of Plant Medicine, Chungbuk National University, Korea

Drosophila suzukii is a quarantine insect pest that is rapidly spreading in berries. This study was examined the synergistic effect of combination treatment with two fumigants (ethyl formate and phosphine) and cold temperature for *D. suzukii* control on imported grapes. A higher insecticidal effect was observed at 1°C than at 5°C at all developmental stages, However, Combining fumigation with low-temperature treatment causes differences in activity depending on kind of fumigant and *D. suzukii* developmental stage. This study evaluated the effects of 2 fumigants and cold temperature on *D. suzukii* by administering the treatments separately, rather than simultaneously. These results suggest that combination treatment is a strategy that could be useful for *D. suzukii* control on grapes stored at cold temperatures for export.

Key words: *Drosophila suzukii*, postharvest quarantine treatment, fumigation, cold treatment, ethyl formate, phosphine

S1-4

Proposal of guidelines using ethyl formate of exotic invasive pests, *Solenopsis invicta*, through commercial trials on imported miscellaneous goods

Dong Bin Kim[1], Tae Hyung Kwon[1], Kyung Won Kim[2], Jung-joon Park[3,4] and Byung-ho Lee[1]
[1]Institute of Quality and Safety Evaluation of Agricultural Products, Kyungpook National University, Daegu
[2]Animal and Plant Quarantine Agency, Gimcheon
[3]Institute of Agriculture and Life Science, Gyeongsang National University, Jinju
[4]Department of Plant Medicine, Gyeongsang National University, Jinju

With the increase in global trade, introduction and establishment of invasive pests have been detected in quarantine processes. Thus, development of treatment guidelines that can effectively control these pests in traded goods in needed. *Solenopsis invicta*, one of the invasive pests that are highly toxic and have a risk of destroying the ecosystem, have been detected in South Korea when importing miscellaneous goods. In this study, the efficacy of ethyl formate (EF), as methyl brodmie (MB) alternatives, was evaluated against *S. invicta*, and based on efficacy data, a commercial trials were conducted on miscellaneous goods including lumber, stone products, rubber trees. It was carried out 100% mortality of insect pests, and there was no damages on miscellaneous goods.

Key words: ethyl formate, hitchhiking insects, miscellaneous goods,

S1-5

Phytotoxic mechanisms and reduction methods of major quarantine fumigants through transcriptome analysis

Kyeongnam Kim[1], Chaeeun Kim[1], Jinsung Yoo[2], Jun-Ran Kim[2] and Sung-Eun Lee[2]
[1]Department of Applied Biosciences, Kyungpook National University, Deagu 41566
[2]Plant Quarantine Technology Center, Animal and Plant Quarantine Agency, Gimcheon 39660

As global commerce expands, quarantine is becoming increasingly important to limit the entry of pests from other countries. Methyl bromide (MB) is the most global fumigant in the plant quarantine field, despite being selected as an ozone-depleting substance through the Montreal protocol. The use of MB is essential until alternatives to MB are established. The time and concentration standards of fumigants are set based on the concentration-time (Ct) values from the bioassay using insect pests, but plants are also affected by fumigant in closed environment. However, the mechanism of phytotoxicity to fumigants was not yet well understood. In this study, *Arabidopsis thaliana*, model plant, was used to evaluate the phytotoxic effect under the quarantine standards, and the unknown toxic mechanism was investigated through transcriptomic analysis. In addition, methods for reducing phytotoxicity were proposed in the study of transcriptome-based mechanisms.

Key words: Phytotoxicity, methyl bromide, phosphine, transcriptomics, mode of action

S1-6

The risk of Methyl bromide fumigation work on the quarantine area

Min-Goo Park[1] and Jungmi Choi[2]
[1]Department of Bioenvironmental Chemistry, Jeonbuk National University
[2]Human Anti-Aging Standards Research Institute

To investigate the risk of methyl bromide fumigtion on workers, electroencephalogram (EEG), heart rate variability (HRV) indices and urinary bromide ion (Br-) were measured in fumigators before and after fumigation work. All fumigators' post-work EEG, HRV indicators were significantly changed towards a weakening of the subjects' nervous systems compared with the pre-work values. The mean pre- and post-work concentrations (7.13 and 15.04 μg/mg CRE) of urinary Br- in the fumigator group were higher than those in the inspector group (3.76 and 4.06 μg/mg CRE), indicating an increase in post-work Br- concentrations compared with the pre-work levels.

Key words: fumigators, quarantine inspectors, EEG, HRV, unrinary bromide ion, methyl bromide

S2-1

The role and value of online site (Gonchoong-nara Sikmool-nara) to expand the base of insects

Soo Jeong Ahn
Agricultural Corporation ERANG CP., Ltd.

인터넷 커뮤니티란 공통의 관심사를 가진 이들이 소통하는 웹사이트로 온라인 커뮤니티라는 명칭으로 쓰이기도 한다. 곤충과 식물을 주요 대상으로 만들어진 네이버 카페 곤충나라 식물나라는 2005년 12월 05일에 개설되었으며 현재 약 16,000여명의 회원으로 구성되어 있다. 개설 당시에는 소모임 또는 동호회 성격을 띠었지만 현재는 전문가와 일반인 또는 매니아들을 이어주는 가교역할을 하고 있다. 일반인들이 전국 각지에서 올리는 사진 중 신종 또는 미기록종이 다수 있으며, 이 경우 전문가와 연결하여 논문으로 출판되기도 한다. 한편, 게시글 작성 시 촬영날짜와 장소를 기록하는 곤충 센서스를 실시하고 있어 국내 곤충의 분포 데이터베이스 자료를 구축하고 있으며, 일정 기간에 올라오는 사진 자료를 통해 곤충 발생 과 분포 등의 양상을 파악할 수 있다. 곤충나라 식물나라 사이트 이용의 극대화는 자료 검색에 있으며 이를 위하여 태그를 의무화하고 있다. 태그는 분류체계를 바탕으로 하고 있고, 자료의 정확성을 위하여 학명과 국명 등은 최신 자료(현재 국가생물종목록 2021, 한국곤충명집 2021)를 바탕으로 수시로 업데이트 하고 있다.

검색어: 온라인 커뮤니티, 인터넷, 곤충, 식물, 곤충나라 식물나라

S2-2

Research history of Korean hoverflies (Diptera: Syrphidae)

Deuk-Soo Choi
Quarantine Technology Institute Inc., Korea

꽃등에과(파리목: 등에아목)은 전 세계적으로 6,000종 이상이 기록되어 있는 파리목 내에서 가장 종 다양성이 높은 그룹에 속하며, 꽃가루받이와 해충의 생물학적 방제용 천적으로 생태계에서 중요한 역할을 하는 것으로 알려져 있다. 특히, 성충의 몸은 화려한 색깔과 다양한 형태로 변형되어 있으며, 꽃에서 쉽게 발견되는 생태적 특징으로 인해 사진 동호인들에 인기가 많은 분류군이다. 한국산 꽃등에는 1906년 제주도에서 배짧은꽃등에가 보고된 것이 최초의 기록이다. 그 후 Shiraki (1930)에 의해 27종이 기록되었고, 1994년 발간된 한국곤충명집에서 127종으로 정리되었다. 현재 지속적으로 분류학적 연구를 통해 70속 212종이 기록되어 있으며, 이 과정에서 '곤충나라식물나라'와 같은 온라인 사이트에 등록된 사진 등이 미기록종을 확인하는데 많은 도움이 되었다. 그러나, 아직도 많은 분류군들이 동정되지 못하고 있어, 실제로 국내에 분포하는 꽃등에과 곤충은 300종 이상이 될 것으로 추정된다. 특히, *Cheilosia, Epistrophe, Sphaerophoria, Pipaza* 등 형태적으로 종간 구분이 어려운 분류군의 경우 형태 및 분자생물학적 형질을 이용한 종합적인 연구가 필요한 것으로 판단된다.

검색어: 꽃등에과, 파리목, 미기록종, 한국, 곤충나라 식물나라

S2-3

How to take insect close-up photography

Sang-il Lee
Taejeon Chung-cheong Industrial Safety HQ

사진은 크게 풍경, 인물, 접사 정도로 나눌 수 있고 그 외 다큐, 기록사진, 보도사진, 상업사진 등 사진의 목적에 따라 그 분야는 매우 다양하다. 이 중 접사 사진이란 피사체를 실제보다 크게 보여주는 것으로 작은 피사체를 극단적인 클로즈업을 통해 찍은 사진이다. 여러 가지 접사 중에서 가장 어려운 분야가 곤충 접사라 할 수 있는데 이는 피사체 크기가 작고 움직임을 통제할 수 없어 마음먹은 대로 사진을 찍기 어렵기 때문이다. 따라서 많은 사람들이 접사를 시도하다가 포기하며, 접사를 즐기는 매니아들 중에서도 많은 어려움을 토로하고 있는 실정이다. 곤충 접사에 적합한 장비로는 카메라 바디(body) 외에 접사렌즈와 플래쉬 등이 있으며 찍는 방법은 곤충 종에 따라 다양한 방법이 요구된다. 이에 사진에 대한 기본적인 원리를 이해함은 물론, 특히 클로즈업(Close up), 마크로(Macro) 촬영이라고 일컫는 접사촬영에 대해 설명하고자 한다.

검색어: 접사 사진, 곤충 촬영, 마크로, 클로즈업, 장비, 곤충나라 식물나라

S2-4

Recent research trends of Vespidae in Korea

Moon Bo Choi
Institute of Plant Medicine, Kyungpook National University

한국에서는 1990년대 중반부터 분류학적 연구를 시작으로 본격적인 말벌과(Vespidae)의 연구가 시작 되었다. 그러다 2003년 부산에서 침입외래종 등검은말벌 (*Vespa velutina nigrithorax*)이 발견되었고 2010년대부터 양봉장에서 등검은말벌 피해가 급증하면서 이를 계기로 말벌류의 다양한 연구들이 진행되고 있다. 최근 말벌류의 연구는 크게 분류, 생태, 방제, 활용 등 총 4가지 분야로 연구가 진행되고 있으나 관련 전문가의 부족으로 연구의 큰 진전이 없는 상태이다. 분류학적으로는 아직 일부 종의 분류학적 논란이 해결되지 못하고 있는 상황이며 최근 말벌 기생자들에 대한 분류학적 연구가 활발히 진행되고 있다. 생태적으로는 비행행동, 포식행동, 방어행동과 같은 행동학적 연구와 더불어 외래종 확산 및 유입 감시, 도시 내 말벌 증가, 기후변화에 따른 종 분포 변화, 희귀 말벌의 생태 등의 연구가 진행되고 있다. 방제 연구로는 말벌 트랩, 벌집 추적 기술, 천적 활용 기술, 벌집 제거 기술 개발 등의 연구가 진행되고 있고 마지막으로 말벌의 활용 연구로는 말벌 독, 말벌 영양분, 벌집 추출물 분석 및 사육 등과 같이 식용곤충으로서의 가능성에 대한 연구가 활발히 진행되고 있다.

검색어: 말벌과, 등검은말벌, 말벌 행동, 말벌 방제, 식용곤충, 곤충나라 식물나라

S2-5

Biology and Immature stages of *Autocrates maqueti* Drumont, 2006 (Coleoptera: Trictenotomidae)

Hee-Wook Cho
Department of Zoology, Nakdonggang National Institute of Biological Resources

사슴하늘소속(*Autocrates*)은 한국, 중국, 동남아시아에서 5종이 보고되었으나, 생태와 미성숙단계는 전혀 알려지지 않았다. 국내에서는 영양사슴하늘소(*A. maqueti*)가 영양군에서 처음 발견된 후 동해안 지역으로 확산되고 있다. '21년 7월 경북 영양군에서 암컷 2개체를 채집하여 서식 생태와 산란 특성을 최초로 확인하였다. 성충은 야행성으로 수액과 젤리를 먹으며, 나무껍질이나 참나무 먹이통 아래의 틈에 긴 산란관을 이용하여 50~600여 개의 알을 낳는다. 알은 6~8일이 지나면 부화하는데, 3~4일간 집단행동을 보이다 분산된다. 1령 유충은 2.6~3.3mm로 몸이 길고 납작하며, 빠르게 이동한다. 2령 유충부터는 동종포식이 나타나 분리사육을 실시하였다. 유충은 잡식성으로 열대어용 사료, 밀기울, 곤충젤리, 냉동 장구벌레 등을 섭식하고, 사육통에 깔아둔 발효톱밥이나 상토 아래로 터널을 만들어 숨는 특성이 있다. 종령 유충은 몸길이 11cm에 연노랑색으로몸표면에 세로 융기선들이 잘 발달하였다. 땅속에서 번데기방을 만들며, 번데기는 5.5cm 크기이다.

검색어: 영양사슴하늘소, 분포, 유충, 생활사, 곤충나라 식물나라

S3-1

Pheromone studies in forest science

Junheon Kim
Forest Entomology and Pathology Division, National Institute of Forest Science

First identification of forest insect pest pheromone in Korea may be the sex pheromone of *Matsucoccocus thunbergianae* in 1989 by Webster, Silverstein et al. Since then, in 2009, the aggregation pheromone of *Platypus koryoensis*, the vector of Korean oak wilt disease was identified by Korea Scientists. For last 30 years, the pheromone of about 10 species was identified and the researches have been mainly focused on re-investigation of previous known pheromone, such as the sex pheromones of *Dioryctria abietella* and *Conogethes punctiferalis.* The utilization of the pheromone for pest management was not performed actively so far. For pest management, the pheromones have been considered as a eco-friendly methods. Recently, in order to apply the pheromone in forest pest management, some researches are performing. The effect of mating disruption of *Conogethes punctiferalis* are investigated for the ultimate purpose of aerial spraying of mating-disrupting agents and pheromone identification of urban forest insect pests are ongoing for development of mating disruption.

Key words: pheromone, mating disruption, forest insect,

S3-2

Development of the pheromone trap for monitoring *Monochamus alternatus* Hope and *Monochamus saltuarius* Gebler

Min-Jung Huh, Il Nam, Ji-Hong Park, Jae-Woo Lee, Dong-Ho Lee, Min-Woo Lee, Soung-Bin Cho and Il-Kwon Park

Department of Agriculture, Forestry and Bioresources, College of Agriculture and Life Sciences, Seoul National University

Monochamol (2-undecyloxy-1-ethanol) is the male-produced aggregation-sex pheromone of *Monochamus alternatus* Hope and *Monochamus saltuarius* Gebler. It is the main component of the pheromone lure for monitoring the *Monochamus* spp. In this study, various trap colors and different combinations of semiochemicals were tested to maximize the attraction of the pheromone lure. The black trap attracted more both *Monochamus* beetles than other color traps. There was a negative correlation between trap catch of beetles and trap lightness. Traps baited with limonene, β-pinene and β-caryophyllene with pheromone+α-pinene+ethanol and ipsenol attracted more *M. saltuarius*. No significant difference in the number of trap catch was observed between the enantiomers of α-pinene and limonene. Four times dose of pheromone and ipsenol increase the trap catch of M. saltuarius, whereas four times dose of pheromone and (-)-α-pinene attracted more *M. alternatus.*

Key words: pheromone trap, semiochemicals, *Monochamus alternatus, Monochamus saltuarius*

S3-3

The beginning and future of domestic insect pheromone industry

Seongchae Jung

AD Corp.

국내 곤충페로몬 산업의 상업적 관점의 원년은 "성페로몬을 활용한 사과해충들의 발생예찰과 방제체계 개발" 연구보고서가 발표된 2001년 이후일 것이다. 연구보고서를 통해 주요 사과 해충에 대한 페로몬 활용 예찰 및 방제 매뉴얼이 만들어졌고, 복숭아와 배 등 다른 과수에서도 동시에 사용하였다. 예찰의 경우 성페로몬 합성과 루어 및 트랩 제작이 국내 기술로 이뤄졌고 현재도 그렇다. 교미교란제는 당시 기술적 한계로 국내 과수 재배환경에 적합한 제품을 수입하여 보급하였다. 현재 국내 예찰 기술은 보고서에 보인 7종의 나비목을 넘어 노린재목, 딱정벌레목, 벌목까지 다양해졌으며, 높은 정확도를 보이는 무인 예찰 기기도 활용하고 있다. 교미교란제는 최초 보급한 수입 제품이 건재하며, 2012~2016년 국산화 시도가 있었으나 호응 없이 사멸했다. 2018년에 개발된 국산 제품은 현재 수입 제품 이상의 판매를 올리고 있다. 곤충페로몬 산업의 미래는 시장 확대에 있다. 국내 시장은 물론 국제 시장까지 필요하다. 시장 확대는 자연스러운 국내 기술의 발전과 안정적 공급체계 및 시장 활성을 만들 것이고, 기술적으로 고도화한 제품이 등장할 것이다.

검색어: 곤충페로몬 산업, 국내 기술, 예찰, 교미교란제

S3-4

Identification and field evaluation of host fruit odor attractive to oriental fruit fly

Gwang Hyun Roh[1], Paul E. Kendra[2] and Dong H. Cha[3]

[1]Department of Plant Medicine and Institute of Agriculture & Life Sciences, Gyeongsang National University
[2]USDA-ARS, Subtropical Horticulture Research Station, Miami, Florida, USA
[3]USDA-ARS, US Pacific Basin Agricultural Research Center, Hilo, Hawaii, USA

Oriental fruit fly, *Bactrocera dorsalis* (Hendel)(Diptera:Tephritidae), is one of the most destructive invasive pests of tropical fruit and vegetable crops worldwide. Considering the importance of kairomones in courtship and oviposition site selection behavior of *B. dorsalis,* we identified host fruit volatile compounds using gas-chromatography linked to electroantennographic detection (GC-EAD), and evaluated the attractiveness of various chemical blends in laboratory bioassays and field trapping experiments. The number of male and female flies captured in traps baited with a blend of EAD active compounds were significantly greater than the number of flies captured in control traps (baited with water) in the laboratory and field, indicating a potential to develop a host fruit based lure for detection and monitoring of *B. dorsalis*

Key words: *Bactrocera dorsalis,* attractiveness, GC-EAD, chemical lure, trapping

S3-5

The first nationwide monitoring of black pine bast scale, *Matsucoccus thunbergianae* by using pheromone trap images

Il-Kwon Park[1,2], Il Nam[1], Jae-Woo Lee[1], Min-Woo Lee[1], Dong-Ho Lee[1], Kyung-Joo Hwang[1], Soung-Bin Cho[1] and Byung-Chan Kim[1]

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

The black pine bast scale (BPBS), *Matsucoccus thunbergianae*, is a major insect pest of black pine and causes serious environmental and economic losses in forests. Therefore, it is essential to monitor the occurrence and population of BPBS, and a monitoring method using traps baited with matsuone, sex pheromone of BPBS, is commonly employed. However, the counting of small insects performed by humans in these pheromone traps is labor intensive and time consuming. To improve the efficiency of pheromone traps, we developed automated deep learning counting algorithms using pheromone trap images. The pheromone traps collected in the field were photographed in the laboratory, and the images were used for training, validation, and testing of the detection models. In addition, the image cropping method was applied for the successful detection of small objects in the image, considering the small size of BPBS in trap images. The detection and counting performance were evaluated and compared for a total of 16 models under eight model conditions and two cropping conditions, and a counting accuracy of 95% or more was shown in most models. This accuracy made it possible to conduct nationwide monitoring for BPBS. Here, we introduce the short history of BPBS monitoring by using pheromone traps and automatic pest counting program.

Key words: Sex pheromone trap, *Matsucoccus thunbergianae*, deep learning, monitoring, automatic counting

S3-6

Future prospects of tools and applications in chemical ecology

Kye Chung Park
New Zealand Institute for Plant and Food Research

Pheromones and other semiochemicals have been developed for practical applications in IPM and biosecurity, reducing non-target impacts and the use of toxic pesticides. The development of practical tools for using semiochemicals has been accelerated with advanced research tools and new scientific insights. The contribution of semiochemicals in IPM and biosecurity practices is likely to increase over the next years with growing concerns regarding environmental protection and climate changes. The development of semiochemical tools requires multidisciplinary efforts, typically including chemical, electrophysiological, ethological and ecological research components. The incorporation of new components such as molecular tools and IT technologies, as well as the technical advance of typical research tools, can further enhance the efficacy of semiochemical use and widen their applications. In this context, this presentation will introduce current efforts to develop new semiochemical-related practical tools and discuss some of their key aspects.

Key words: chemical ecology, IPM, kairomone, olfaction, pheromone, semiochemical

S3-7

Sex pheromones of major lepidopteran pests of food crops in Korea

Jin Kyo Jung and Eun Young Kim
Crop Cultivation and Environment Division, Natl. Institute of Crop Science

We arranged the sex pheromone studies, in 22 lepidopteran pests of food crops – rice, legume crops, maize, root and tuber crops, and oil crops, which were conducted in Korea, and then discussed their availability for usage. The sex pheromones of 4 species were identified using domestic populations, and those of other 3 species were evaluated as reasonable compositions for attraction of target insects in fields. Those of 16 species including the 7 species have been used for monitoring, but researches about more accurate composition and other biological traits are required. Necessity of monitoring-relevant studies such as species identification, estimation of actual crop damage, and decision of control strategies were mentioned for efficient IPM. Automation of monitoring process and bio-engineered synthesis of sex pheromones were suggested as another goals of pheromone studies.

Key words: food crops, lepidopteran insects, sex pheromones, application, future study

S4-1

RNAi, genome editing and epigenetics in insects

Subba Reddy Palli
Department of Entomology, University of Kentucky, Lexington, KY 40546, USA

RNA interference (RNAi) technology is being utilized in research to advance understanding of insect biology and develop methods to control insect pests. However, the efficiency of RNAi is viable among insect species, highly variable in coleopteran insects to ineffective in lepidopteran insects. Recent studies in our laboratory identified major contributors to the differential efficacy of RNAi among insects. We also developed nanoformulations to improve RNAi efficiency in lepidopteran insects. CRISPR/Cas9 mediated genome editing methods were developed to knockdown genes in the fall armyworm and the yellow fever mosquito. Modifications to these methods, including the use of transgenic insects and multiple sgRNAs improved target gene knockout efficiency. The improved genome editing methods were used to study functions of genes involved in hormone action in the fall armyworm and the yellow fever mosquito. DNA and core histone modifications influence chromatin organization and expression of the genome. Histone modifications regulate development and reproduction in the red flour beetle and yellow fever mosquito. Acetyltransferases, deacetylases, methyltransferases, and demethylase genes have been identified in the red flour beetle and yellow fever mosquito genomes. Studies on the function and mechanisms of action of some of these enzymes uncovered their contributions to post-embryonic development and reproduction.

Key words: CRISPR/Cas9, fall armyworm, yellow fever mosquito, epigenetics, red flour beetle

S4-2

Novel insight into molecular mechanism underlying dynamic insect molting

Yasuyuki Arakane
Department of Applied Biology, Chonnam National University

During molting, insects need to deposit a new cuticle simultaneously with turnover of the old one by molting fluid enzymes including epidermal chitinases (CHTs). However, the degradation of cuticular chitin by CHTs presents several challenges because of the crystallinity of anti-parallel α-chitin chains. The gene family encoding lytic polysaccharide monooxygenases (LPMOs), which catalyze oxidative cleavage of glycosidic bonds in crystalline polysaccharides, has been identified recently in insects. RNAi of *LPMO15-1* of *Tribolium castaneum* caused molting arrest at all developmental stages with a failure of degradation of cuticular chitin. We propose that the LPMO15-1 could act to oxidatively cleave chitin chains, which generates new ends and aids in delamination of chitin crystallites that would be accessed and hydrolyzed by CHTs to completely digest chitin in the old cuticle during insect molting.

Key words: cuticle/exoskeleton, lytic polysaccharide monooxygenase, chitinase, molting/ecdysis

S4-3

Olfactory communication in insects

Kye Chung Park
New Zealand Institute for Plant and Food Research

Olfactory signals mediate a wide range of intraspecific and interspecific communications, playing a key role for important behavioral responses in insects. With increasing research activities and advances of research tools in recent decades, new insights on the physiology and underlying mechanism on the olfactory communication of insects have been obtained across wide areas spanning from molecular mechanism to complex multitrophic interactions. The application of new electrophysiology and organic chemistry tools in insect chemical ecology has enabled the practical use of sex pheromones and other semiochemicals in effective monitoring and direct management of insect pests. However, some key aspects of insect olfactory communication, are yet to be fully understood. More information is need to understand how the stereotypic olfactory responses are elicited and how the plasticity of behavioral responses is controlled. Chemical signals are able to convey accurate species-specific messages in intertwined odor environment in complex ecosystems. Although chemical communication is relatively well understood in simplified systems, chemical communication in more complex and realistic systems is less understood. This talk will review our current understanding on the olfactory communication of insects and discuss future research needs.

Key words: chemical communication,chemical signals, olfaction, semiochemical

S4-4

Eicosanoid biosynthesis inhibitors to develop novel insecticides

Yonggyun Kim
Andong National University

Eicosanoids are a group of oxygenated C20 polyunsaturated fatty acids and include prostaglandins (PGs), leukotrienes, and epoxyeicosatrienoic acids (EETs). Most of them are synthesized from a C20 precursor called arachidonic acid (AA), which is esterified to glycerol skeleton of phospholipids. Phospholipase A_2 (PLA_2) catalyzes the release of free AA, which is oxygenated into different eicosanoids. Unlike vertebrates, terrestrial insects lack in AA probably to minimize lipid oxidation damage. They have specific long fatty acid elongase and desaturases to transform C18 linoleic acid to AA. Although lipoxygenase is yet to be identified in insects, cyclooxygenase (COX)-like peroxynectin and epoxidases catalyze AA to produce PGs and EETs, respectively. These eicosanoids mediate various insect physiological processes including immunity and reproduction. Eicosanoids mediate cellular and humoral immune responses to various microbial pathogens including virus, bacteria, fungi, and protozoans. Recently, damage-associated molecular pattern (DAMP) signaling is also functionally associated with eicosanoids. It is interesting that some entomopathogens suppress host insect immune responses to protect themselves. For example, *Xenorhabdus* and *Photorhabdus* are well known to produce various secondary metabolites to inhibit PLA_2 to suppress insect immunity. Thus, these bacterial metabolites can be applied to enhance the virulence of other entomopathogens. Furthermore, PGs mediate the oocyte development in female adults. Treatment of a COX inhibitor, aspirin, prevent vitellogenesis by inhibiting nurse cell dumping during the early oocyte development. In addition, PGs mediate chorion formation at the late oocyte development. These suggest that COX inhibitors prevent insect reproduction. Altogether, eicosanoid biosynthesis inhibitors can be applied to develop novel insecticides.

Key words: eicosanoid, immunity, reproduction, insecticide

S4-5

Pheromone Biosynthesis as putative control targets in the Bean pod borer, *Maruca vitrata*

Wook Hyun Cha and Dae-Weon Lee
Department of SmartBio, Kyungsung University

Pheromone biosynthesis in the pheromone gland is stimulated by pheromone biosynthesis activating neuropeptide (PBAN) produced in the suboesophageal ganglion. PBAN binds its receptor and induces biological signal into the molecules for the pheromone biosynthesis. Transcriptomes of the pheromone gland in *Maruca vitrata* were analysed and a total of 191 contigs involved in the pheromone biosynthesis. Putative pheromone biosynthetic pathways for sex pheromone components were proposed through transcriptomic analysis. To investigate the possibility that pheromone biosynthesis-related gene can be a control target, pheromone gland-specific fatty acyl-CoA reductases (pgFAR) was identified through transcriptome sequencing of its pheromone gland. *M. vitrata* pgFAR (Mvi-pgFAR) was cloned from the pheromone gland and suppressed by RNA interference (RNAi). Mvi-pgFAR harbored several conserved motifs related to NAD(P)H-binding, N-glycosylation, and adenosine / guanosine triphosphate binding. Mvi-pgFAR was specifically expressed only in the pheromone gland. Quantitative real-time polymerase chain reaction showed that the diurnal expression levels of Mvi-pgFAR in the pheromone gland were the highest at 2 h before the scotophase. After primarily confirming Mvi-pgFAR suppression by RNAi, (E,E)-10,12-hexadecadienal (E10E12-16:Ald), a major sex pheromone component, was quantified by gas chromatography. When Mvi-pgFAR was successfully suppressed, E10E12-16:Ald production was reduced by up to half of that of the control, and the mating rate was subsequently decreased. Our results demonstrate that Mvi-pgFAR down-regulation can suppress mating behavior by changing the relative sex pheromone component ratio, suggesting that Mvi-pgFAR can be used as a novel control target.

Key words: *Maruca vitrata*, Pheromone, pgFAR, PBAN, RNA interference, control

S4-6

Cold tolerance: unravel the mysterious story of overwintering in insects

Youngjin Park
Plant Quarantine Technology Center, Animal and Plant Quarantine Agency, Gimcheon 39660, Korea

Insects face a challenge in surviving at extremely low temperatures in temperate zone. Therefore, overwintering survival is one of important factors to limit insect distribution. The cold tolerance has been gained by adaptive responses to various environments with biological, physiological, and endocrinological adjustments in insects. Low temperature acclimation accumulated cryoprotectants in insect hemolymph that increased survival by decreasing supercooling point (SCP) as well known as rapid cold hardening (RCH). Lepidoptera insects such as the fall armyworm, the beet armyworm, and the diamondback moth generally used glycerol or trehalose as cryoprotectant for increasing survival at extremely low temperature. These phenomena reported in various other insects including the red imported fire ant and *Solenopsis japonica* in Hymenoptera, the flesh fly in Diptera, and the palm thrips in Thysanoptera. RNA interference experiments showed that RCH correlated with cryoprotectants and cold tolerance. Therefore, the RCH plays a crucial role in freeze-susceptible insect and may use as survival strategy to withstand any sudden cold temperatures.

Key words: Cold tolerance, rapid cold hardening, supercooling point, cryoprotectant, glycerol

S5-1

Global biodiversity of the family Lecithoceridae (Gelechioidea) with recent taxonomic studies

Kyu-Tek Park
The Korean Academy of Science and Technology, Seoul, Korea

The family Lecithoceridae (Lepidoptera, Gelechioidea) is one of the more poorly known groups of microlepidoptera, even though it is a highly diverse group containing more than 1,470 known species so far. During last two decades since the end of 1990 years, author has intensively studied for the family Lecithoceridae, especially for the less explored areas including Southern Asia, Oceanian and Afrotropical regions. Throughout these studies, the author (often with his co-authors) described a new subfamily Crocanthinae, 32 new genera, and over 540 new species of the family. In this study, a historical review for the taxonomic works of the family since the comprehensive study, “Microlepidoptera Palaearctica, Lecithoceridae” by Gozmany (1978), is briefly summarized, with the comparison of the number of genera/species of each subfamily, and the number of the species by the subfamily in each region of the world. All available information on the phylogeny, biology, morphological characters of subfamilies, and zoogeographical remarks for the distribution of family are discussed and listed.

Key words: Afrotropical, Lepidoptera, Lecithoceridae, Madagascar, Oriental, Oceanian, Palaearctic, review, taxonomy

S5-2

Reclassification of the family Tephritidae (Diptera) with notes on the diversification of pest taxa: worldwide taxon sampling, morphological and molecular approaches

Ho-Yeon Han and Kyung-Eui Ro
Division of Biological Science and Technology, Yonsei University, Mirae Campus, Wonju-si, Korea

Despite of the economic importance and years of conventional systematic studies, the classification of the family Tephritidae is still in a state of flux. In the process of revising the higher classification of Tephritidae and related families (Tephritid Tree of Life Project), we have made a significant improvement based on DNA analysis (mt 16S, 12S, COI and COII genes). In an effort to make balanced taxon sampling of as many phylogenetic lineages as possible from all over the world, we have so far accumulated fresh samples of 570 species of 220 tephritid genera covering 11% and 44% of world species and genera, respectively. We here report our new phylogenetic classification of the family Tephritidae, including the followings: (1) expanded concept of the family Tephritidae encompassing the previous families Pyrgotidae, Ctenostylidae, Tachiniscidae and Tephritidae; (2) recognition of the seven monophyletic (Pyrgotinae, Ctenostylinae, Blepharoneurinae, Epacrocerinae, Acanthonevrinae, Dacinae, and Tephritinae) and one paraphyletic (Trypetinae) subfamilies; and (3) recognition of at least 37 monophyletic tribes.

Key words: Tephritoidea, Tephritidae, mitochondria, molecular phylogeny, classification

S5-3

Fauna of Hemipteran Insects in the Korean Peninsula

Seunghwan Lee[1,2], Minsuk Oh[1,2], Geonho Cho[3], Jinyeong Choi[4] and Minho Lee[1,2]

[1]Insect Biosystematics Laboratory, Seoul National University, Seoul 08826, Korea
[2]Research Institute of Agriculture and Life Sciences, Seoul National University, Seoul 08826, Korea
[3]Department of Forest Resources, Sunchon National University, Suncheon 57922, Republic of Korea
[4]Evolution, Cell Biology, and Symbiosis Unit, Okinawa Institute of Science and Technology Graduate University, Okinawa, Japan

The order Hemiptera is the only one which could be listed within the big 5 insect orders, comprising of ca. 99,280 species worldwide (c.a. 10.8% of total Insecta with 913,200 species), which is subdivided into 4 suborders, Authenorrhyncha(cicadas, leaf hoppers, plant hoppers etc), Coleorrhyncha, Heteroptera (true bugs), Sternorrhyncha (aphids, scale insects, psyllids, whiteflies etc), and Coleorrhyncha (moss bugs or beetle bugs, a single extant family in the southern hemisphere only: Australia, New Zealand, New Caledonia, and South America).

Up-to-date, a total of 2189 species within 96 families has been recorded in the Korean Peninsula, which is c.a. 11.8% of total insect fauna (19,490 spp.).. It is a comparatively well studied insect order in the Korean Peninsula, since, as armed with typical sucking and piercing mouthparts, members of hemipteran insects are economically important, due to not only as direct herbivorous insect pests but also as natural enemies and transmitting various plant diseases.

The history of systematic studies on Hemiptera is revised with the discussion of endemism and alienism in the Korean Peninsula, as the family Aphididae as a model group.

Key words: Hemiptera, Aphididae, Taxonomic history, Korean Peninsula, Endemism, Alienism

S5-4

A current status of phylogenetics on the flat wasps (Hymenoptera: Chrysidoidea: Bethylidae)

Jongok Lim[1] and Celso Oliveira Azevedo[2]

[1]Department of Life and Environmental Sciences, Wonkwang University, Iksan, Korea
[2]Departamento de Ciências Biológicas, Universidade Federal do Espírito Santo, Vitória, Brazil

The flat wasps mean members belonging to the family Bethylidae (Hymenoptera: Chrysidoidea). This family involves most diverse species in the superfamily with 2,920 taxa and most of them are recorded from tropical regions. The bethylids have two different ecological features; most species are regarded as natural enemies against for agricultural and forestry insect pests, otherwise some species are recorded as pests in house conditions. In the presentation, we would like to introduce the Bethylidae with current status of phylogenetic studies as well as discussion why we have to emphasize the studies on Hymenopteran taxa for sustainable systematics on Korean wasps.

Key words: Bethylidae, flat wasps, insect pest, natural enemy, taxonomy.

S6-1

Seasonal occurrence of wood-boring bark beetles (Coleoptera: Curculionidae) from coniferous forest in the border of South and North Korea

Jongok Lim[1], Seung-Hwan Oh[2], Sangwook Park[3], Haneul Yu[1], Jaewoo Yeom[1], Jeongwoon Won[1], Seokmoo Kang[1], Suyeon Shin[1], Youngwoo Nam[4], Yonghwan Park[4] and Chansik Jung[4]

[1]Department of Life and Environmental Sciences, Wonkwang University, Iksan, Korea
[2]Longicornia Insect Institute, Cheolwon, Korea
[3]Research Institute of Forest Insect Diversity, Namyangju, Korea
[4]Forest Entomology and Pathology Division, National Institute of Forest Science, Seoul, Korea

Scolytine species are one of most important wood-boring insect pests in the world. Most of them are tiny and have wide range of hosts. Recently, there are many cases have been reported that various coniferous trees are damaged by many wood-boring insects and other reasons. In this study, we established a total of 30 Lindgren funnel traps in Gwangwon region: 10 traps in Cheolwon (Yeongseo region); 10 traps in Yanggu and 10 traps in Inje (Yeongdong region) to investigate the diversity of bark beetles from June to September. As results, we provided a list of bark beetles and discuss about the seasonal occurrence of them for each region.

Key words: Bark beetle, Gangwon province, Korea, occurrence, Scolytinae

S6-2

Importance of pollination in ecosystem functioning and its conservation with IPPM paradigm

Chuleui Jung

[1]Department of Plant Medicals, Andong National University, Republic of Korea
[2]Agriculture Science and Technology Research Institute, Andong National University, Republic of Korea

Pollination is one of the ecosystem services provided from biodiversity which contribute the proliferation of plant diversity and agricultural production. Here the contribution of pollination services provided by bees and other pollinators to crop production in the world and in Korea specifically. Then the ongoing efforts to conserve the pollination as well as pollinators in my lab are detailed; pollinator habitat suitability mapping, pollinator-antagonist (Vespa hornets) distribution mapping; honey bee conservation of two competing species; Apis mellifera and A. cerana, as well as the toxicological works against the pollinators. Finally integrated pollinator-pest management (IPPM) concept was proposed as the advanced philosophical paradigm for agricultural biodiversity management option.

Key words: honey bee, pollination, crop production, ecosystem service, metabarcoding, spatial distribution

S6-3

Insect ecology, What to do in agricultural pests?: With special emphasis on new smart technologies

Dong-soon Kim, Subin Kim, Myeongeun Jwa and Yonggyun Shin
College of Applied Life Science, SARI, Jeju National University

농작물 해충의 방제에서 곤충생태학은 그동안 중심적인 역할을 수행하였다. 현실적인 측면에서 생태와 방제라는 등식이 일반화 되었고 지배하였다. 기본적으로 곤충의 생태는 어떤 주어진 환경하에서 한 종이 생활사를 완성하는 생활계로 볼 수 있으며, 이를 구명하기 위한 다양한 생태적 기술들이 적용되었다. 그 중에서 해충방제와 연관된 최고 관심사는 개체군의 크기를 파악하고 동태를 추적하는 기술이다. 이 위에서 방제는 대상해충 모집단의 크기를 줄이든지 제거하든지 아니면 방해하여 더 크게 발달하지 못하도록 하는 종합적인 조치이다. 해충의 생활계가 펼쳐진 지도처럼 상세히 밝혀져 있고 실시간 추적이 가능하다면 방제는 손쉽게 달성된다. 곤충 생활계는 빅데이터와 같이 양(volume)과 다양성(variety) 측면에서 정형 및 비정형의 데이터를 간직하고 있다. 근래의 발달하는 다양한 스마트 기술들은 분명 해충 생활계를 보다 더 정확하게 이해하는데 긴요한 수단이 될 수 있다. 본 발표에서는 해충예찰에 활용되는 스마트 트랩을 중심으로 곤충생태학이 무엇을 할 것인지 고찰하고자 한다.

검색어: 스마트 기술, 해충방제, 생활계, 개체군 추정, 빅데이터, 곤충생태학

S6-4

Density estimation of the insect population in smart farm system using machine learning model

Jung-Joon Park[1,2], Taechul Park[1], SoEun Eom[1], Kimoon Son[1], Ji-won Jeong[1] and Mincheol Kim[1]
[1]Department of Plant Medicine, Gyeongsang National University, Korea
[2]Institute of Agriculture and Life Science, Gyeongsang National University, Korea

Density estimation is the central part of integrated pest management strategy of insect pests. Classical methods are based on the spatial distribution using mean and variances of target pests by laborious sampling in target crop fields. Recently, remote environment monitoring and control systems are applied in commercial greenhouses, *i.e.* smart farm system. Smart farm system logged all environmental variables including temperature, RH and so on. Environmental variables affecting the density fluctuation of insect pest selected atmosphere factors (temperature and RH), soil factors (temperature, moisture, and EC), and host factors (photosynthesis potential, photosynthesis rate, and NDVI). In this study, insects density were estimated using machine learning model with environmental variables for smart farm system.

Key words: Density estimation, Smart Farm System, Machine Learning Model, *Bemisia tabaci*, *Franklniella occidentalis*

S6-5

Implementing classical biological control of pests in Korea

Ikju Park
School of Applied Biosciences, Kyungpook National University

Pests, unwanted organisms that negatively interfere with an ecosystem, have been a significant problem in Korea; Biological control has been efficient in suppressing pests worldwide. Among the three biological control strategies, classical biological control programs have rarely been implemented in Korea because one of the concerns is the environmental safety of biological control agents before implementing them in Korea. I will provide three case studies for pre-release risk assessments and post-release monitoring programs: 1. Biological control of houndstongue in North America from 1997 to 2021; 2. Mass-rearing approved biological control agents for yellow starthistle in California from 1980 to 2022; 3. Initiating classical biological control of box tree moths from 2021 to the present. With the International Organisation for Biological Control-Asia and Pacific Regional Section (IOBC-APRS), Korea will become one of the leading countries in classical biological control of pests for the next 40 years, moving forward to celebrate the 100th anniversary of KSAE in 2062.

Key words: classical biological control, insect pests, invasive plants, IOBC-APRS, weeds

S6-6

Case studies on the function and evolution of insect coloration

Changku Kang
Department of Agricultural and Biotechnology, Seoul National University, Seoul, South Korea

Research on the function of coloration is a vibrant area in insect ecology. One of the main areas of insect coloration research is investigating them as an adaptation to avoid predation. Camouflage is the most common form of anti-predator coloration, and many insects have evolved behavioural strategies to improve their camouflage. However, their camouflage is never perfect, and some insects have evolved various backup defences in case their camouflage fails, which are called secondary defences. In this talk, I will present research on insect secondary defences mainly concerning deimatic and flash displays both of which use bright hindwing coloration.

Key words: anti-predator, coloration, secondary defence

S6-7

Asymmetrical exploitation of immature fruits by two *Grapholita* spp.

Un Taek Lim[1] and Souvic Sarker[2]
[1]Department of Plant Medicals, Andong National University
[2]Department of Entomology, Rutgers University, New Brunswick, NJ, USA

문헌에 따르면 복숭아 과실에서는 복숭아순나방이, 자두 과실에서는 복숭아순나방붙이가 주로 발견된다. 이 현상을 설명하기 위해 1) 유충의 미성숙 과실에 대한 선호성의 차이(differential host preference)와 2) 생존율의 차이(differential survivorship)에 의한 것이라는 가설을 세우고 검증하였다. 복숭아순나방 유충은 자두에 비해 복숭아를 행동적으로 더 선호했지만, 복숭아순나방붙이는 자두를 더 선호하여 1)번 가설과 부합하였다. 다만, 복숭아 과실 내에 침투한 복숭아순나방붙이 유충의 탈과율만이 유의하게 감소하였고, 자두 과실 내에 침투한 복숭아순나방 유충의 탈과율에는 차이가 없어, 2번 가설은 부분적으로 수락하였다. 성숙도가 다른 복숭아 과실로 추가 검증한 결과 복숭아순나방 유충은 채집일이 늦은 과실에서 산란수와 내적자연증가율(r_m)이 증가하여, 먹이 질(당도와 경도)의 변화가 두 나방의 생존율에 영향을 준다는 것을 추론할 수 있었다.

검색어: 복숭아순나방, 복숭아순나방붙이, 사과, 자두, 발생 패턴, 기주 이용

S7-1

Characterization, impact and spread of diamide insecticide resistance in lepidopteran pests with special reference to ryanodine receptor alterations

Ralf Nauen
Bayer AG, Crop Science Division, R&D, 40789 Monheim am Rhein, Germany

Diamide insecticides, selectively acting on insect ryanodine receptors (RyR), were commercialized approx. 15 years ago. They particularly target lepidopteran pest species in diverse agronomic and horticultural cropping systems. Diamides are globally registered in many countries and provide reliable control levels in most settings. However, their frequent application, due to a lack of effective alternative modes of action, has resulted in the selection of diamide resistance in some of the world's most destructive lepidopteran species, including diamondback moth, tomato leafminer, rice stem borer and beet armyworm. High levels of diamide resistance, compromising diamide efficacy at recommended label rates, have been shown to be particularly conferred by RyR target-site mutations affecting diamide binding. Recently RyR target-site mutations were also described in fall armyworm, *Spodoptera frugiperda*, a pest which only a few years ago invaded the Eastern Hemisphere including Asia-Pacific. The presentation reviews past and present research on diamide insecticide resistance mechanisms in lepidopteran pests, with special reference to RyR target-site alterations. Furthermore, principles enabling the prediction of the impact and spread of diamide resistance, based on population genetics and molecular studies will be discussed.

Key words: *Spodoptera exigua, Spodoptera frugiperda*, Ryanodine receptor, Diamide

S7-2

Target-site and metabolic mechanisms of resistance in fall armyworm

Debora Boaventura[1] and Ralf Nauen[2]

[1]Bayer CropScience, S.L., Avda Comarques del País Valencià 267, 46930 Quart de Poblet (Valencia), Spain
[2]Bayer AG, Crop Science Division, R&D, 40789 Monheim am Rhein, Germany

Fall armyworm (*Spodoptera frugiperda*) is a polyphagous lepidopteran species, causing significant damage in several economically important crops, particularly corn. It is a major pest in North and South America, but very recently invaded the African continent and East Asia.

The control of this pest relies on synthetic insecticides and genetically engineered crops expressing *Bacillus thuringiensis* (Bt) crystal (Cry) toxins. However, fall armyworm developed resistance to different insecticide chemical classes and since 2014, field-evolved Cry1F-resistance has been observed in Brazil.

In this study, the molecular mechanisms conferring resistance to Cry1F was characterized in fall armyworm populations collected in Brazil and cross-resistance pattern with chemical insecticides and Bt toxins were investigated. Moreover, the involvement of detoxification enzymes as well as possible target-site mutations in different insecticides targets were analyzed and new gDNA-based diagnostic tools developed to support fall armyworm resistance management strategies.

Key words: *Spodoptera frugiperda*, Ryanodine receptor, Diamide, *Bacillus thuringiensis*

S7-3

Increased oxidative bioactivation is responsible for highly selective coumaphos toxicity to varroa mites, *Varroa destructor*

Si Hyeock Lee
Department of Agricultural Biotechnology, Seoul National University

To elucidate the molecular basis of the selective coumaphos toxicity between honey bees and varroa mites, the toxicodynamic and metabolic natures of coumaphos were compared. The selective toxicity of honey bees to coumaphos was 810-fold lower, whereas the selective toxicity of honey bees to malathion was only 12.1 fold lower compared to varroa mites. Inhibition assay using in vitro expressed acetylcholinesterases (AChEs) revealed that honey bee AChE was significantly more sensitive to coroxon compared to any of the three AChEs from varroa mites, suggesting that AChE insensitivity is not responsible for reduced coumaphos toxicity in honey bees. *In vivo* metabolic profiling of coumaphos based on LC-MS/MS indicated that coroxon is more rapidly and abundantly generated in varroa mites than in honey bees perhaps due to differential coumaphos bioactivation mechanism. In contrast, malaoxon was rapidly generated in both varroa mites and honey bees, further suggesting that the significantly reduced coumaphos-specific bioactivation is likely the main cause for the differential coumaphos toxicity between the two species. Cross-species comparison of the expression profiles of cytochrome P450s (P450s) with putative detoxification or bioactivation function in the nervous system indicated that a larger proportion of bioactivation P450s is expressed in varroa mite synganglion than in the honey bee brain ventral nerve cord. The relatively more abundant expression of bioactivation P450s in synganglion appears to contribute to the selectively high coumaphos toxicity to varroa mites.

Key words: Honey bee, Varroa mite, Coumaphos, Selective toxicity, Bioactivation, Cytochrome P450, Acetylcholinesterase

S7-4

Effect of soybean volatiles on the behavior of the bean bug, *Riptortus pedestris*

Junyong Song[1], Gisuk Lee[1], Jinkyo Jung[2], Jung-Kyung Moon[2] and Sang-Gyu Kim[1]
[1]Department of Biological Sciences, KAIST, Daejeon, South Korea
[2]National Institute of Crop Science, South Korea

The bean bug, *Riptortus pedestris*, is a polyphagous insect that feeds primarily on leguminous plants, especially soybean (*Glycine max*). Although the bean bug is an economically important pest of soybean, little is known about how the insect locates soybean fields. In this study, we examined the electroantennogram responses of *R. pedestris* to soybean volatiles and examined behavioral responses of the adult bean bugs. *R. pedestris* adults were attracted more to their host-plant soybean, even when physical contact was absent, than to air or to a non-host plant. Accordingly, we hypothesized that *R. pedestris* can recognize soybean through a plant's volatile organic compounds (VOCs). Five VOCs were identified from intact soybean plants at the vegetative stage: (Z)-3-hexen-1-ol, (Z)-3-hexenyl acetate, 4-ethylbenzaldehyde, α-farnesene, and methyl salicylate. Response spectra of the antennae to these volatiles clearly showed that both male and female *R. pedestris* can detect soybean volatiles. The adult bean bugs did not show behavioral orientation to any individual compounds, but showed significant orientation to a particular blend of synthetic soybean volatiles when tested under the laboratory conditions. In the field, this soybean volatile blend did not significantly attract the bean bugs, but it did interact synergistically with the aggregation pheromone to attract the bean bugs. These results highlight the role of host plant volatiles in the sensory ecology of *R. pedestris* and help explain colonization pattern of the bean bugs in soybean fields.

Key words: *Glycine max*, host-plant volatile, *Riptortus pedestris*, olfactory response, aggregation pheromone

S7-5

First things first: why does optimal defense theory matter for crop production

Youngsung Joo
Department of Biological Sciences and Biotechnology, Chungbuk National University, Cheongju, Chungbuk 28644, Republic of Korea

Plants are attacked by various herbivores, and many herbivores attack specific plant tissues. However, studies on plant defense have not yet taken into account the feeding specificity of herbivores. Similarly, damage to crops is also caused by specific herbivores in specific tissues. In order to control pests more effectively, it is essential to understand the specificities of plant tissues and organs, so that plant traits can be bred according to these differences. My presentation will focus on how our research group is studying the optimal defense strategy for plants based on *Capsella bursa-pastoris* and its herbivores.

Key words: tissue-specific defense, optimal defense theory, plant resistance, feeding guild

S7-6

Flavonoid-associates defense of aquatic weeds, *Lemna perpusilla* and *Lemna minor* against duckweed weevil, *Tanysphyrus lemnae* attack

Gisuk Lee[1], Hanyoung Choi[2], Youngsung Joo[2] and Sang-Gyu Kim[1]
[1]Department of Biological Sciences, KAIST, Daejoen
[2]Department of Biological Sciences and Biotechnology, Chungbuk National University, Cheongju

Plants in the aquatic environment face various herbivore threats, as do terrestrial plants. Despite growing in similar environments, duckweed plants may have different survival strategies. In this study, free-floating plants, *Lemna perpusilla* and *Lemna minor*, studied for the species-specific defense against herbivorous insects called duckweed weevils, *Tanysprus lemnae*. The duckweed weevil female deposited much more eggs and fed on better in *L. perpusilla* species. Although herbivore-induced jasmonic acid (JA) levels did not differ between *Lemna* species, flavonoid levels differed markedly. Particularly, *L. perpusilla* grew much faster than *L. minor*, but under duckweed weevil, the content of isoorientin, vitexin, and isovitexin in *L. minor* species was significantly higher than in *L. perpusilla*. Herbivore performance were significantly decreased by these three flavonoids. These results suggested that the difference in the content of flavonoid substances have consecutively preformed to be species-specific as different defense-related functions against duckweed weevil attack.

Key words: aquatic plant, duckweed, duckweed weevil, plant defense

S8-1

Molecular genetic and structural analysis of mosquitocidal bacterial toxins

Hyun-Woo Park
Department of Biological Sciences, California Baptist University, Riverside, California, U.S.A.

Among many insecticidal bacteria, *Bacillus thuringiensis* subsp. *israelensis* (Bti) that produces Cry4Aa, Cry4Ba, Cry11Aa and Cyt1Aa, and mosquitocidal strains of *Lysinibacillus sphaericus* (Ls) that produces BinA and Bin B have been extensively used in order to control vector mosquitoes that transmit important diseases such as malaria, West Nile, Zika, and dengue fever worldwide. To understand the activity of the mosquitocidal toxin proteins produced by Bti and LS, 5' and 3' genetic elements of the *cyt1Aa* gene that encodes the largest crystal toxins in Bti were analyzed. In addition, the chimeric protein using Cyt1Aa, and BinA that is not normally crystallize without BinB was constructed. While researches for the past few decades have made us enhance the activities of the mosquitocidal toxins, we do not understand their structures and crystallization much. Therefore, Cyt1Aa and Cry11Aa from Bti, and Cry11Ba from Bt subsp. *jegathesan* (Btj), another mosquitocidal Bt subspecies were analyzed using point mutations and serial femtosecond crystallography in terms of *in vivo* crystallization.

Key words: *Bacillus thuringiensis*, *Lysinibacillus sphaericus*; mosquitocidal; femtosecond crystallography

S8-2

Synthetic biological approach to develop improved insecticides

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

Bacillus thuringiensis (Bt) produces insecticidal crystal protein which have been used as a major ingredient of most bio-insecticides. The use of Bt in synthetic biology is highly desirable to take advantage of the unique metabolic pathways in this organism for enhanced toxicity, and delay of resistance development. In this study, it was intended to generate a stably improved strain with a broader insecticidal host range. Additionally, simultaneous Bt-based dsRNA and Cry toxin-producing platform was established. In particular, these system facilitates the pest management of honeybee virus using RNA interference, and lepidopteran pest utilizing Cry toxins.

Key words: *Bacillus thuringiensis*, synthetic biology, RNA interference, honeybee virus

S8-3

Identification of differential DNA methylated regions between different development of entomopathogenic fungi, *Beauveria bassiana* NCHU-157, by Nanopore sequencing

Yi-Hsuan Li[1], Ju-Chun Chang[1], Ming-Ren Yen[1], Yu-Feng Huang[1,2], Tzu-Han Chen[1] and Yu-Shin Nai[1*]
[1]Department of Entomology, National Chung Hsing University, Taichung City, 40227, Taiwan
[2]Department of Computer Science and Engineering, Yuan-Ze University, Tao-Yuan City 32003, Taiwan

The DNA methylome of *Beauveria bassiana* (Bb-NCHU-157) was investigated by Oxford Nanopore Technologies (ONT). The whole genomic DNA methylation of Bb-NCHU-157 in mycelium stage (5mC= 3.44%, CG= 2.39%, CHG= 0.58%, CHH= 0.47%) is higher than that of conidia stage (5mC= 2.06%, CG= 1.57%, CHG= 0.27%, CHH= 0.22%) in both gene and transposon elements (TE) regions and the higher methylation frequency were found in TE region. Total 1262, 794 and 123 differential DNA methylated regions (DMRs) are hypermethylated in mycelium, for CG, CHG, and CHH, respectively. Genes in the DMR commonly involve in DNA binding (GO:0003677), DNA-binding transcription factor activity, RNA polymerase II-specific (GO:0000981), nucleic acid binding (GO:0003676) and protein serine/threonine kinase activity (GO:0004674) for hypermethylated in mycelium. These data will be further validated and explored to the epigenetic regulation during development of *B. bassiana*.

Key words: Oxford Nanopore Technologies (ONT); entomopathogenic fungi (EPF); *Beauveria bassiana*; DNA methylation; differential DNA methylated regions (DMR)

S8-4

Behavioral control of disease vector by entomopathogenic fungi

Daigo Aiuchi
Research Center for Global Agromedicine, Obihiro University of Agriculture and Veterinary Medicine, Japan

Entomopathogenic fungi have potential for controlling adult mosquitoes which could prevent the transmission of infectious diseases. Our previous studies have focused on the behavioral change of fungus infected mosquito on host seeking, blood feeding, and oviposition. Results showed that mosquito attraction to heat, color, and odor cues, frequency and amount of blood feeding, egg production, follicle development, and egg hatching rate were all decreased by fungal infection. Therefore, there is a possibility to inhibit disease transmission by behavioral control using entomopathogenic fungi. In this talk, our recent researches on determination of lethal and behavioral change factors will also be reported.

Key words: *Anopheles stephensi*, *Beauveria pseudobassiana*, behavioral control, entomopathogenic fungi, vector control

S8-5

Use of entomopathogenic fungi for controlling arthropods of one health importance

Juliana Marques Ferreira[1], Filippe Elias de Freitas Soares[1,2] and Everton Kort Kamp Fernandes[1]
[1]Department of Parasitology, Federal University of Goiás, Brazil
[2]Department of Chemistry, Federal University of Lavras, Brazil

The excessive and unplanned use of chemicals has generated several negative impacts on human and animal health; thus, alternative measures to control these pests are urgent. Entomopathogenic fungi may be used as biological control agents of important vectors, such as mosquitoes and ticks. Conidia are widely used commercially; however, other fungal propagules are promising, i.e., blastospores and microsclerotia. Our results indicate that entomopathogenic fungi are efficient control agents against *Aedes aegypti, Rhipicephalus sanguineus, Rhipicephalus microplus,* and *Amblyomma sculptum.*

Key words: entomopathogenic fungi, mosquitoes, ticks, biological control

S8-6

Environmentally sound soil pest management: ERL836 and JEF-503 against thrips and nematodes

Jae Su Kim[1], Soeun Park[1], Yeram Im[1], Insoo Jeon[1], Yujin Jeong[1], Yulim Park[1], Kijung Kim[1], Gahyeon Song[1], Putri Novadhea[1], Hanna Yang[1] and Jong-Cheol Kim[1]
[1]Department of Agricultural Biology, Jeonbuk National University, Korea;
[2]Department of Agricultural Convergence Technology, Jeonbuk National University, Korea

For crop production, pesticides are frequently used to control soil-dwelling pests but soil-contamination causes unexpected adverse effect in environment. In this work, we tried to control soil-dwelling thrips and root-knot nematodes using entomopathogenic fungi. ERL836 GR and WP (Chongchaesak™) have been successfully developed and this fungal isolate is very effective against thrips management. Secondly a fungal isolate, JEF-503 was highly virulent against root-knot nematode and it could be industrialized after formulation and field studies.

검색어: pesticide, thrips, root-knot nematode, ERL836, formulation

S9-1

Tick bites causing red meat allergy

Yoonseong Park
Department of Entomology, Kansas State University, 123 Waters Hall, Manhattan, KS 66506, USA

Tick bites are thought to be the cause of alpha-Gal syndrome (AGS, also known as red meat allergy), which is characterized by urticaria and anaphylaxis in response to dietary red meat. AGS, a chronic disorder for a life-time, is caused by an unusual occurrence of enhanced IgE antibody production against galactose-alpha-1,3-galactose (aGal), which is a common glycan in mammalian tissues, with the exceptions of old word monkies and humans. A growing number of cases of AGS have been reported in the Southeast and Midwest regions of the United States (U.S.), with some 34,000 documented cases from 2010-2018, which also occur in South Korea. Numerous studies have strongly supported the notion that the bites of the lone star tick, *Amblyomma americanum*, are the cause of AGS in U.S. Interestingly, however, AGS occurs in only a small subgroup of the overall human population experiencing tick bites, indicating that either a subpopulation of ticks are the culprits of change or that a subpopulation of humans are vulnerable for development of IgE against aGal, causing AGS. We have demonstrated that the salivary glands (SG) of *A. americanum* contain aGal glycosylated protein, the presumed AGS sensitizer. A number of studies, including ours, have successfully expanded the scopes by using alpha-galactosyltransferase knockout mutant (aGT-KO) mice as the AGS model system. In an expanded study for identifying the source of tick aGal, surprisingly, we found significant variations in aGal levels in *A. americanum* SG due to host type, as well as to individual tick variation; i.e., ticks fed on human blood produce high levels of aGal, with large variations among individual ticks. Combining this discovery with the facts indicating on-going dynamic changes in the *A. americanum* populations in the U.S., including endosymbiont composition, we study aGal variations among individual ticks and tick populations, while also extending our scope to include clinical AGS in an aGT-KO mouse.

Key words: alpha-gal, Red meat allergy, tick

S9-2

Cholinergic control of tick salivary glands

Ladislav Simo

ANSES, INRAE, Ecole Nationale Vétérinaire d'Alfort, UMR BIPAR, Laboratoire de Santé Animale, Maisons-Alfort, France

For over four decades, it has been known that injection of the muscarinic acetylcholine receptor (mAChR) agonist, pilocarpine, into partially-fed hard tick females, induces robust long-lasting salivary gland (SG) secretion, whereas it fails to induce saliva from isolated SG. We molecularly characterized two distinct mAChRs (type A and B), both being expressed in *Ixodes* SG and synganglion. Our reporter systems, revealed that stimulation of mAChR-A triggers intracellular Ca^{2+} mobilization, whereas that of mAChR-B leads to cAMP elevation. We also confirmed that only receptor A is sensitive to pilocarpine. Using cholinergic marker, we uncovered a direct cholinergic axonal connection between distinct cells in *Ixodes* synganglion and non-saliva producing type I SG acini and suggested its role in osmoregulation for atmospheric humidity absorption by desiccated ticks. Using epitope-specific antibodies, we localized both mAChR types in *Ixodes* SG and synganglion. Immunostaining confirmed the presence of both receptors in epithelial cells of type I acini, which is not surprising, as these structures are the targets for synaptic cholinergic signals. However, aside from this immunosignal, we spotted strong reactions in two distinct innervations of saliva producing acini type II and III. Specifically, the antibodies recognized mAChR-A in axons innervating exclusively type II acini, while mAChR-B immunoreaction was found in axonal projections innervating both type II and III acini. Furthermore, we revealed that both axonal mAChRs-A or -B are colocalized with different classes of neuropeptides originating from specific neurons in the synganglion. In addition, our results suggest that the *Ixodes* SG is a pool of acetylcholine as both, choline acetyltransferase, the enzyme synthetizing acetylcholine, and vesicular acetylcholine transporter, that loads the acetylcholine to secretory granules, are expressed in this tissue. Based on these findings, we propose that two distinct cholinoceptive neuropeptidergic axonal pathways innervating several hundreds of type II and III acini are sensitive to paracrine acetylcholine, arising from acinar cells to mediate the feedback signal back to peptidergic neurons in the synganglion. Taken together, our results indicate that axonal communication between synganglion and SG is bidirectional, synganglion-to-SG and SG-to-synganglion, regulated by peptidergic and cholinergic signals, respectively.

S9-3

A practical approach for assaying tick saliva proteins in tick research

Myungjo You

Laboratory of Veterinary Parasitology, College of Veterinary Medicine and Bio-safety Research Centre, Chonbuk National University, Jeonju 561-756, Korea

Ticks secrete and inject saliva into its hostto control the feeding site and counteract the host defenses, of which contains hundreds of different proteins and other pharmacologically active molecules that confer anti-hemostatic, anti-inflammatory and immunomodulatory properties, supporting blood feeding. Therefore, the identification and characterization of novel saliva proteins could point to candidates for the development of anti-tick and transmission-blocking vaccines, understanding host-tick interaction and of new pharmacological active molecules for medical application. Salivary proteins discovery has primarily on analysis of genome sequences. But, RNA-based approaches only provide indirect evidence of protein expression, and some of the translation products may be unstable, cannot provide data on post-translational modifications, other processing steps like signal peptide cleavage, or maturation that proteins can undergo. Mass spectrometry-based proteomics provides a direct method to detect and quantify salivary proteins on a global or targeted scale. In addition, MS can also provide information on the different proteoforms. The identification and functional characterization of tick saliva proteins is useful to understand tick biology and to conceive new anti-tick control methods. We collected *Haemaphysalis longicornis* tick saliva from nymphs and adults for LC-MS/MS sequencing and peptides were searched against tick. A total of 135 tick protein were identified of which 30 proteins were identified exclusively in fully engorged nymph saliva, 74 in fully engorged adult females, and 31 were detected in both stages. The identified tick proteins include heme/iron metabolism-related proteins, oxidation/detoxification proteins, enzymes, proteinase inhibitors, tick-specific protein families, and cytoskeletal proteins. Proteins involved in signal transduction, transport and metabolism of carbohydrate, energy, nucleotide, amino acids and lipids were also detected. This study allows the identification of *H. longicornis* saliva proteins. Here we discussed the major tick salivary protein families involving immunomodulation, inhibition of hemostasis and inflammation. Moreover, we discuss the potential, opportunities, and challenges in searching for novel tick-derived drugs.

Key words: Assay, Tick, Saliva, Protein, Research

S9-4

Vaccine development for severe fever with thrombocytopenia syndrome virus

Jun-Gu Kang
Korea Zoonosis Research Institute, Jeonbuk National University, Iksan 54531, Korea

Severe fever with thrombocytopenia syndrome (SFTS) is an emerging infectious disease caused by SFTS virus (SFTSV). SFTSV is associated with a high mortality rate and has been reported in China, Japan, Taiwan, and Korea. SFTSV is mainly transmitted through tick bites, especially from *Haemaphysalis longicornis*, which is the dominant tick species in East Asia. Recent studies showed the prevalence of SFTSV in various domestic animals, including cattle, goats, chickens, cats, dogs, horses, and wild animals. Despite a gradual increase of SFTS cases and high mortality in endemic regions, no specific viral therapy nor vaccine is available. However, several vaccine studies using DNA plasmid, recombinant proteins, attenuated virus, and recombinant virus for SFTSV have been reported in China and Korea. Here, I show several data related to SFTSV vaccine development using recombinant protein and DNA plasmid.

Key words: SFTSV, SFTS, Tick, Vaccine

S9-5

Tick and Tick-borne disease pathogen surveillance in the Republic of Korea

Hee Il Lee, Seong Yoon Kim, Tae Yun Kim and Min-Goo Seo
Division of Vectors and Parasitic Diseases, Korea Disease Control and Prevention Agency, Chungju, Korea

Tick was known to transmit several pathogens include Severe Fever with Thrombocytopenia Syndrom (SFTS), Lyme borreliosis, and Tick-borne Encephalitis. For the tick-borne disease management, we survey tick distribution, seasonal prevalence, and its pathogen infection status. In Korea, *Haemaphysalis longicornis*, SFTS vector, is most dominant species (>90%) in the field. However, *Amblyomma testudinarium* is relatively popular (17.8%) from human bitten ticks. Tick incidence varied from April to October, with population peaks observed for nymphs in May, adults in July, and larvae in September. *H. longicornis*, *H. flava*, and *I. nipponesis* were mostly distributed nationwide, whereas *A. testudinarium* was found only in the southern and western areas of the country. After tick collected by dry ice baited trap in the field, we tested SFTSV infection and identified 0.2% MIR. From the wild rodent, we collected ticks and identified lyme borelliosis and babesiosis pathogens. Ticks were analyzed using nested PCR targeting partial flagellin B gene sequences and found 33.6% of *Borrelia* infection. Most common genospecies were *B. afzelii* (62.5%) followed by *B. valaisiana* (31.9%), *B. yangtzensis* (2.4%), *B. garinii* (1.6%), and *B. tanukii* (1.6%). *Borrelia afzelii* was found in all regions except Jeju Island. On the other hand, *B. yangtzensis* and *B. tanukii* were only found on Jeju Island. In addition, we also detected *Babesia* spp. using amplification of the 18S rRNA and revealed the presence of *B. duncani*, *B. venatorum*, *B. capreoli/divergens*, and, the most prevalent, *B. microti* in the ticks. We also detected *Anaplasma phagocytophilum* and *Ehrlichia* spp. in infested tick from human. In three individulas (1.7%; 95% CI: 0.3–4.9), *A. phagocytophilum* was detected in Ixodes ticks using primers for Anaplasma-specific genes (16s rRNA, ankA, and msp4). Conversely, *Ehrlichia* sp. was only detected in *H. longicornis*, in two cases (1.1%; 95% CI: 0.1–4.0). These kinds of surveillance can helpful to make tick and tick-borne disease control strategy.

S10-1

Mechanisms influencing RNA interference efficiency in the European corn borer

Anastasia M. W. Cooper and Kun Yan Zhu
Department of Entomology, Kansas State University, USA

The European corn borer (ECB), *Ostrinia nubilalis*, is an agriculturally important lepidopteran pest that exhibits low RNA interference (RNAi) efficiency. We investigated some of the mechanisms influencing RNAi efficiency in ECB and tested commonly used reagents for improving RNAi efficiency. *Ex vivo* incubation experiments showed that double-stranded RNA (dsRNA) was degraded in ECB gut contents and hemolymph under physiologically relevant pH conditions. Further analysis revealed transcripts for four dsRNA-degrading endonuclease (OndsRNase) genes and one RNAi efficiency-related nuclease (*OnREase*) gene. Expression analysis indicated that OnREase, OndsRNase2, and OndsRNase4 might impact RNAi efficiency by dsRNA ingestion, whereas OnREase and OndsRNase1 may impact RNAi efficiency by dsRNA injection. Sequencing also revealed a single transcript for Dicer 2 (*OnDcr2*), R2D2 (*OnR2D2*), and Argonaute 2 (*OnAgo2*). Expression analysis indicated that these genes were expressed in all ECB developmental stages and tissues investigated. *Ex vivo* incubation experiments showed that Metafectene Pro, chitosan-based nanoparticles, EDTA, and Zn^{2+} enhanced dsRNA stability in ECB gut contents and hemolymph, but Lipofectamine RNAiMax, Co^{2+}, and Mn^{2+} did not. Surprisingly, improving dsRNA stability did not increase RNAi efficiency in ECB *in vivo*. Ingestion-, injection-, and tissue culture-based RNAi assays indicated that most target genes and all ECB developmental stages investigated were highly refractory to RNAi. These findings suggest that multiple mechanisms likely contribute to low RNAi efficiency in ECB. This investigation is expected to help improve RNAi efficiency in lepidopteran insects, so effective RNAi-based biopesticides can be developed.

Key words: *Ostrinia nubilalis*, RNAi, double-stranded RNA, agriculture, biopesticides, lepidoptera

S10-2

Functions and Potentials of the Coleoptern-specific dsRNA Binding Protein, StaufenC

June-Sun Yoon[1] and Subba Reddy Palli[2]
[1]Department of Agricultural Convergence Technology, Jeonbuk National University, Jeonju, South Korea
[2]Department of Entomology, College of Agriculture, Food and Environment, University of Kentucky, Lexington, KY 40546

Staufen proteins belong to a family of RNA-binding proteins (RBPs) and play an important role in RNA localization in many organisms. Staufen2 in mammals regulates mRNA localization, mRNA stability, translation, and ribonucleoprotein (RNP) assembly. In insects, genome database suggests that there seems to be only one Staufen. However, in coleopteran, there are two types of Staufen protein and we found that one of them are highly involved in RNAi (RNA interference) pathway in terms of double-stranded RNA binding characteristic which affects RNAi susceptibility. Here, I would like to introduce coleopteran specific double-stranded RNA binding protein (StaufenC), especially its functions and potentials.

Key words: Staufen, RNAi, dsRNA, StaufenC

S10-3

Chitin deacetylases are necessary for insect muscle attachment to cuticle and mobility

Mi Young Noh[1], Seulgi Mun[2], Erika R. Geisbrecht[3], Karl J. Kramer[3], Subbaratnam Muthukrishnan[3] and Yasuyuki Arakane[2]

[1]Department of Forest Resources, Chonnam National University
[2]Department of Applied Biology, Chonnam National University
[3]Department of 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 for group I CDAs in insect locomotion and muscle attachment. 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. RNAi for *TcCDA1* or the alternatively spliced *TcCDA2* isoform, *TcCDA2a*, in the red flour beetle, *Tribolium castaneum* 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 cuticular 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.

S10-4

Application of DNA-based molecular techniques in medical entomology

Ju Hyeon Kim

Department of Tropical Medicine and Parasitology, Seoul National University

Various DNA-based molecular techniques have been widely employed in the field of medical entomology for solving several urgent issues such as the detection of specific genetic traits of pest populations, analysis of species composition in pest groups, and clinical diagnosis of arthropod infection. Quantitative sequencing (QS) protocols have been developed to predict the insecticide resistance allele frequencies in field populations of medical pests as the first step resistance monitoring tool in a tier system. The performance of QS-based resistance monitoring has been proven successful in predicting the resistance levels to pyrethroid and organophosphrus insecticides in a rapid and precise manner in human lice, bed bugs, *Anopheles* spp. and *Culex* spp. The QS has been also adapted for establishing an analytical tool to predict and identify species composition ratio within the *Anopheles* Hyrcanus group, facilitating the studies on the *Anopheles* group vector ecology and malaria epidemiology. The loop-mediated isothermal amplifcation (LAMP) protocol has been developed for the clinical diagnosis of scabies from patient's skin scraping samples. The LAMP-based diagnosis is rapid and sensitive by enabling the on-site detection of scabies with a minimum amount of sample. Future prospects and applicability of molecular diagnostic techniques for the management of vector populations and vector-borne diseases will be discussed.

Key words: lice, bed bug, mosquito, scabies, quantitative sequencing, LAMP

S10-5

Comparison of AMP expression putatively involved in environmental chemical tolerance between two *Drosophila* species

Young Ho Kim
Department of Entomology, Kyungpook National University

Drosophila suzukii and *Drosophila melanogaster* are taxonomically close species. *D. suzukii* inhabits fresh fruits, while *D. melanogster* is mainly found in decaying and fermenting fruits, and is exposed to environmental chemicals, such as 2-phenylethanol, ethanol, and acetic acid, produced by microorganisms. Considering their distinct habitats, *D. melanogaster* is hypothesized to be more tolerance to the chemicals than *D. suzukii*. In this study, as expected, *D. melanogaster* exhibited higher survival rate than *D. suzukii* following exposure to the chemicals. Transcriptional analysis of *D. melanogaster* treated with chemicals revealed up-regulation of AMPs, and expression levels of AMPs in *D. melanogaster* were higher than that in *D. suzukii*. A transgenic RNAi fly silencing AMPs exhibited significantly reduced survival rates than the control fly, suggesting AMPs play an important role in the chemical tolerance of *D. melanogaster*.

Key words: *Drosophila melanogaster*, *Drosophila suzukii*, Antimicrobial peptides, Tolerance

S11-1

Silk is a biomedical metamaterial: Seven hidden functionalities

Young L. Kim
PhD, MSCI Associate Head for Research and Professor | Weldon School of Biomedical Engineering
Showalter Faculty Scholar and University Faculty Scholar | Purdue University
Purdue Quantum Science and Engineering Institute
Regenstrief Center for Healthcare Engineering
Purdue University Center for Cancer Research
Purdue University, Indiana 47907, USA

As protein-based biopolymers produced by silkworms, silk is a fascinating biomaterial that has been extensively studied for numerous biomedical applications. Several studies show that silk proteins can be reinforced to superior material properties that often do not exist in naturally occurring materials. This idea has an analogy with the concept of metamaterials and metastructures. In this talk, we will introduce that silk can be extended to a type of metamaterials. We will share our recent progress of better understanding multiple functionalities (optical, mechanical, and biological) of silk as novel nanostructures, nanomaterials, and quantum materials for biomedical, energy, and security applications. Specifically, reinforced silk produced by transgenic silkworms and silkworms fed with special diets could be considered as biomedical metamaterials that are designed for direct utilizations for biological and medical applications. Several key characteristics of silk can be used to develop cyberphysical security technologies for pharmaceutical anticounterfeit measures and authentication features. We further expect that these insights into native silk and reinforced silk can guide better engineering of superior synthetic biomaterials and lead to discoveries of unexplored biomedical and security applications of silk.

S11-2

Development of novel foods and functional materials from insects

Jae Sam Hwang, Joon Ha Lee, Minchul Seo and In Woo Kim
Department of Agricultural Biology, National Institute of Agricultural Sciences, RDA, Wanju-gun Jeonbuk, 55365

It is widely accepted that by 2050 the world will host 9 billion people. To accommodate this number, current food production will need to almost double.Therefore, we need to find new ways of growing food. For this reason, the Food and Agriculture Organization(FAO) of the United Nations reported the possibility of using edible insects in human dietary supplements in the future. The reasons for selecting insects as future food are high growth and feed conversion rates, reproduce quickly, low environmental footprint, valuable source of nutrients, and source of a various undevelopment functional materials. Since 2014, *Tenebrio molitor* larva, *Protaetia brevitarsis* larva, *Allomyrina dichotoma* larva, *Gryllus bimaculatus*, *Zophobas atratus* larva, *Apis mellifera* male pupae and *Locusta migratoria* were registered as new food in korea because it has been scientifically proven that they not harmful to est and nutritious. Therefore they can be legally produced and sold as food. Accordingly, there are 10 species of edible insects including grasshopper, silkworm pupa and Baekgangjam in korea. To improve aversion to edible insects, using their powder, chop and gravy hidden their morphology, we developed more than 200 different kinds of recipes for general food menu, held several times tasting events to be familiar with edible insect food, and published cookbooks. To eat the insect food more and more people, we have been analyzed various function of insects. If health food based on the results of functional analysis is developed, edible insect's valule will be raise. In addition, insect antimicrobial peptides(AMPs) have been focused on developing of a therapeutic agent. Actually, we identified an insect defensin, coprisin, from the dung beetle, Copris tripartitus. Coprisin analog, CopA3, has been previously confirmed to have antimicrobial and anticancer activities including therapy effect of colitis. Moreover, an antimicrobial peptide, Scolopendrasin I, identified from the centipede, Scolopendra subspinipes mutilans. The Scolopendrasin I showed antimicrobial and anti-atopic dematitids effects. Overall, insects are very important resources to overcome a shortage food and they will provide very useful bioactive molecules for our future

Key words: edible insect, peptide

S11-3

Current status and future of research and industry of insect pollinator in Korea

Kyeong Yong Lee, Young Bo Lee, Sankar Kathannan and Hyung Joo Yoon
Department of Agricultural Biology, National Institute of Agricultural Science

화분매개곤충은 인류의 먹거리를 책임지는 중요한 곤충자원이다. 한국에서 화분매개곤충의 경제적 가치는 6.8조원으로 평가되고 있고, 연간 27개 원예작물에서 61.5만 봉군이 농작물의 화분매개로 사용되고 있다. 또한 2020년 현재 시설과채류에서 농가사용율은 67.2%로 매해 꾸준한 성장 추세에 있어 앞으로 유망한 산업으로 평가된다. 국내 화분매개벌의 산업에 관련된 연구는 2000년 이후부터 뒤영벌의 생산, 농작물에서 적용기술에 대한 연구에 중심으로 수행되었다. 현재는 인공수정 등을 통한 우수한 뒤영벌 여왕벌의 계통육성, 스마트 뒤영벌 생산 시스템으로 대표하는 생산성 향상에 대한 연구와 작목별 화분매개벌 이용기술 표준화, 화분매개용 스마트벌통 등 화분매개 효과를 증대하기 위한 연구가 진행되고 있다. 앞으로는 기후변화에 대응한 야생 화분매개벌 자원 보호, 서식예측 모델, 신규 자원의 발굴에 대한 연구가 필요하며, 화분매개벌의 생태적 가치를 증대시키기 위한 새로운 평가 도구가 개발되어야 할 것이다. 아울러 원예작물, 공학, 미생물 등 융복합 연구를 통하여 화분매개곤충의 효용성을 극대화 시킬 수 있는 연구가 수행되어야 할 것이다.

검색어: 화분매개곤충, 꿀벌, 뒤영벌, 양봉, 산업곤충

S11-4

Insect: Current global status and prospects as animal feed

Kwanho Park[1], Bonwoo Koo[1], Young-Soon Kim[1], Eunsun Kim[1], Ji Yeong Park[1] and Ji Sang Yun[2]
[1]Department of Agricultural Biology, National Institute of Agricultural Sciences
[2]Rulal Development Administration

세계식량농업기구(FAO)에 따르면 2050년 세계 인구는 약 97억명에 육박하고, 육류의 수요가 약 4.5억톤에 이를 것으로 예상된다. 현재에도 육류와 어류의 소비가 증가함에 따라 사료로 사용되고 있는 단백질의 공급 충족이 점점 어려워지고 있다. 이러한 사료용 소재의 소비 확대는 기후변화와 더불어 자원의 고갈, 사회경제적 발전과 지구환경의 지속가능성에 심각한 영향을 미치고 있다. 동물사료로서의 곤충 소재의 사용은 앞으로의 변화를 고려할 때 유망한 대체 사료원으로 기대된다. 최근 몇 년 동안 사료소재로서의 곤충은 가축, 양식어, 반려동물 등에 이용과 관심이 급격히 증가하고 있는 추세이다. 사료용 곤충의 산업화는 앞으로 급속한 발전이 기대되고 있으나, 과학적 검증, 기술적 문제, 규제의 장벽 등을 어떻게 풀어나가냐에 따라 산업화의 방향과 규모가 달라질 것으로 본다. 곤충의 사료원료시장 내 확장은 동물사료용 곤충을 생산하기 위한 효율적인 생산, 가공시스템, 규제의 완화와 정책적 지원, 소비자들의 인식의 변화에 따라 곤충이 사료원료로서 산업의 한 분야로 자리매김해 나갈 것이다.

검색어: 곤충, 사료, 지속가능성

S11-5

Current status and future prospects of healing agriculture programs using emotional insects

So-Yun Kim, Jeong-Hun Song, Sun Young Kim and Sangmin Ji
Department of Agricultural Biology, National Institute of Agricultural Sciences

치유사회로 접어들었다. 코로나-19 이후 사회 전반에서 치유에 대한 국민적 관심과 요구가 증가하였고, 공급자 측면에서도 치유서비스를 제공하려는 수요가 증가하고 있다. 이에 2021년 3월 시행된 '치유농업 연구개발 및 육성에 관한 법률' 이후 다양한 농촌의 자원을 이용한 치유농업프로그램에 관한 연구가 진행되고 있다. 그 가운데 '정서곤충'을 이용한 치유농업프로그램은 치유 목적에 적합한 곤충 종을 선발하여 일반인을 대상으로 예방적 차원의 치유로 접근하고 있다. 치유를 목적으로 이용된 대표 종은 왕귀뚜라미, 호랑나비, 장수풍뎅이, 누에나방이다. 관련 연구는 2013년 이후 실제 현장 적용 사례와 효과 구명을 중심으로 수행되고 있으며, 주로 아동과 노인을 대상으로 적용됐다. 앞으로는 치유를 위한 정서곤충 종의 다양화, 치유농장형 시범 농가 및 인력 양성, 대상자의 확대, 참가자 맞춤형 프로그램 개발 등을 기반으로, 곤충 치유산업의 연구개발과 기술보급 및 정책사업 연계 강화를 위한 지원과 제도가 마련되어야 할 필요가 있다.

검색어: 치유사회, 정서곤충, 치유농업프로그램, 치유농업법

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KSAE
60th Anniversary

H1

Comparative Analysis of Stridulatory Apparatus on Order Orthoptera

Junho Choe
Korean Minjok Leadership Academy

메뚜기목(Order Orthoptera)은 수컷이 암컷을 유혹하여 짝짓기하기 위하여 소리를 낸다. 메뚜기목 중 메뚜기아목(Suborder Caelifera)은 앞날개의 단단한 시맥에 뒷다리 넓적다리마디의 미세한 입체 구조인 마찰판을 문질러 울음소리를 내고, 여치아목(Suborder Ensifera)은 좌우 앞날개 기부에 있는 시맥이 변형된 마찰판을 서로 비벼서 소리를 낸다.(김태우, 2013) 메뚜기는 타종 간의 교미를 막기 위하여 종마다 서로 다른 울음소리를 낸다. 메뚜기 울음소리의 주파수는 사람이 들을 수 있는 가청 주파수부터 초음파 파장까지 다양하다. 같은 종 내에서도 상대방의 성별을 확인하기 위하여 암컷과 수컷 메뚜기는 서로 다른 울음소리를 가진다. 메뚜기목의 다양한 마찰돌기의 형태학적인 연구는 메뚜기목의 교미를 이해하는데 필수적인 연구이다. 본 연구에서는 서식하는 메뚜기아목의 여러 종들의 암컷과 수컷의 마찰돌기의 구조를 관찰한 뒤에 개수, 크기, 형태와 같은 차이점을 기록하였다. 관찰 대상 곤충들은 강원도 횡성군 안흥면 봉화로 800, 민족사관고등학교에서 채집되었다

H2

Research on the relationship between *Aeshna crenata* and *Anax nigrofasciatus*

Tae Wook Kim
Hwacheon High School

이 둘은 서식지가 겹치게 되면 먹줄왕잠자리가 참별박이왕잠자리를 일방적으로 포식한다는 이론과 연구가 있다. 하지만 둘의 포식은 자연스럽지 않은 생존을 위한 포식으로 보고 이 둘의 포식은 일어날 수 없다고 생각했다. 포식이 아닌 서식지와 환경의 차이로 생긴 참별박이왕잠자리의 도태가 먹줄왕잠자리가 참별박이왕잠자리를 포식하지 않을까 하는 가설을 세우고 연구를 시작하였다. 첫 번째 연구는 오염에 얼마나 강한지 실험하였는데 그 실험은 둘을 500ml 기준의 생수병에 넣고 먹이만 투여하고 물을 갈아주지 않는 상황에서 얼마나 버티는지 실험하였다.

두 번째는 두 종을 2마리씩 수조에 넣고 물만 갈아주고 7일 동안 어떤 개체가 남아있는지 실험하였다. 세 번째 실험은 두 개체를 종령(성충이 되기 직전까지)까지 키워서 둘의 성장차이를 비교하는 실험을 진행하였다.

H3

Usage of Hanok as Breeding Place by *Subfamily Eumeninae*

Woo Chan Seo and Jin Won Chang
Korean Minjok Leadership Academy

Most species of the *Subfamily Eumeninae*, also known as potter wasps are solitary wasps. Full-grown potter wasps visit flowers to obtain nectar and pollen, while the larvae consume caterpillars as their food source. Therefore, the adult female finds caterpillars and paralyzes them, and brings them back to the nest for its larvae. This research has focused on the study of the lifecycle of *Subfamily Eumeninae*, especially on *O. drewseni drewseni*, *Genus Discoelius*, *Genus Euodynerus*, and *Genus Anterhynchium* which is observed in Korean Minjok Leadership Academy(KMLA). KMLA has hanok, a traditional Korean house which is preferred by potter wasps as their breeding place. The identification key, environmental characteristics of hanok and their nest, and the lifecycle behavior of their mating season have been represented. By analyzing the prey hunted and stored inside the holes by potter wasp species, we have been able to produce data on which species and size are preferred, and have recorded all behavior related to the prey that potter wasps have captured. Also, organisms that share the same habitat with potter wasp species like *Family Chrysididae* has been provided. This research provides the lifecycle of potter wasp in Korean penninsula; especially the species which uses holes and cracks of hanok. This lifecycle informations can be used for the preservation of old hanoks and other wooden cultural properties.

Key words: *Subfamily Eumeninae*, hanok, parasitoid, kleptoparasitism

H4

Nutrition Analyses on Edible Insects: The Prospects of Edible Insect Distillation

Seoin Chloe Yang
Seoul Global High School

본 연구는 식용 곤충의 종별 특성 및 쓰임새를 영양학적으로 분석한 뒤 이의 확장 가능성을 탐구한다. 영양소 및 열량 검출이라는 분석 자체는 단순하나 이를 기반으로 하여 제2의 안을 고안했다는 점에 의의를 둔다. 2022년 10월 기준(한시적 허용 종 포함) 10종의 식용 곤충 중 시장 확장성을 기준으로 하여 *Tenebrio molitor*, *Caelifera*, *Gryllus bimaculatus*, *Bombyx mori* 총 4종의 영양소 및 열량을 비교분석하였다. 실험 결과 4종 중 Tenebrio molitor만 녹말을 비롯한 포도당, 단백질, 지방 등 다양한 영양성분을 함유함을 확인했으며 열량 비교실험에서도 *Tenebrio molitor*이 시간당 온도 상승률이 가장 높았다. 타 종과는 달리 유충이기 때문에 키틴질이 없어 영양분의 흡수가 빠름도 확인했다. 이와 같은 분석을 바탕으로 실제 식품 제조를 시도해보았다. 사전 조사에서 가장 선호도가 높았던 캐러멜에 분말을 배합해 '고소애 캐러멜'을 제조해 단백질 함유량이 일반 캐러멜에 비해 상대적으로 높음을 증명했다.

식감 측면에서 고소애 분말의 이질성을 극복하기 위한 방안으로 증류를 제안한다. 액체 형태의 분말을 기화 후 냉각하는 증류 과정을 통해 영양을 보존하되 식감 문제는 해결하는 것이다. 학생의 신분에서 영양소를 보존하며 증류를 하는 것에 한계를 느껴 실현화 과정은 거치지 못했으나 정통한방 노법 및 증류주 관련 연구를 바탕으로 제2안의 현실성을 주장한다.

PG1

The systemic effect of azadirachtin on the growth, development, and survival of fall armyworm, *Spodoptera frugiperda*

Rajendra Acharya[1,2], Sushant Raj Sharma[2], Ji-Youn Lee[3,4], Lucas Mezione de Carvalho[2], Hwal-Su Hwang[2] and Kyeong-Yeoll Lee[2,3]
[1]Department of Entomology, Kyungpook National University
[2]Department of Applied Biosciences, Kyungpook National University
[3]Department of Plant Protection and Quarantine, Kyungpook National University
[4]Department of Agricultural management, Chilgok Agricultural Technology Center

The fall armyworm (FAW), *Spodoptera frugiperda*, is one of the most important invasive pest species in Africa and Asia. Azadirachtin is a powerful plant-derived natural pesticide which is low toxic to the human and natural environment, and can be used as an alternative to synthetic chemical pesticides for the control of FAW. However, the foliar spray of azadirachtin is not much efficient due to the rapid degradation of the compounds by UV light. We demonstrated whether soil drainage is efficient for FAW control as well as toxic to the corn plants. The soil application of azadirachtin suppressed the growth, development, and survival of FAW but didn't show any phytotoxicity effects on corn plants. This study provides important information of the soil application for persistent effect of azadirachtin as well as no harmful effect on natural enemies of FAW.

Key words: soil drainage, biological control, plant-derived biopesticides, invasion

PG2

Genetic diversity and population structure of Asian tiger mosquito *Aedes albopictus* in South Korea

Jiyeong Shin[1,2], Jongwoo Jung[2,3] and Juil Kim[1,4]

[1]Agriculture and Life Sciences Research Institute Kangwon National University

[2]The Division of EcoCreative, Ewha Womans University

[3]Department of Science Education, Ewha Womans University

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

Aedes albopictus is known to be native to Southeast Asia and has emerged as a major vector for vector-borne diseases that are rapidly spreading worldwide. Recent studies have found that *A. albopictus* populations have different genetic groups depending on their thermal adaptations, but studies on Korean populations are minimal. In this study, we analyzed the genetic diversity and structure of two mitochondrial genes (COI and ND5) and 16 microsatellites in mosquitoes inhabiting Korea, Japan, and Laos. The results indicate that the Korean population has low genetic diversity but has an independent cluster distinct from the Laos population. However, mixed clusters were also observed in Korean populations. Two hypotheses can be proposed based on these results. First, this species has existed in Korea as a native species. Second, it became the Korean meta population after one or more invasions from other countries. These results possibly apply to set the population genetics-based integrated pest management program for the Korean *A. albopictus* population.

Key words: *Aedes albopictus*, Population structure, Genetic diversity, Invasive species

PG3

MicroRNA expression profiling of *Spodoptera frugiperda* and their potential role in diamide resistance

Rashmi M. Mahalle[1], Yu Jaesang[2], Hyun Sik Seong[2] and Keon Mook Seong[2]

[1]Institute of Agricultural Sciences, Chungnam National University, Daejeon, Republic of Korea.
[2]Department of Applied Biology, Chungnam National University, Daejeon, Republic of Korea.

The fall armyworm (FAW), *Spodoptera frugiperda*, is one of the most severe economic pests of multiple crops globally. In order to control this species, the indiscriminate use of insecticides has posed a threat of resistance to the major chemical groups, and most recently to diamides. Previous studies have indicated diamide resistance is a complex development process involving many genes, but information on resistance mechanisms at the post-transcription level is still limited. In this study, a global screen of microRNAs (miRNAs) has been performed with insecticide-resistant and -susceptible strains. We found a total of 109 known and 63 novel miRNAs. Of the identified miRNAs, seven miRNAs were significantly down-regulated, and only two were significantly up-regulated in the resistant strain (1.32 to 2.54-fold) as compared to those in the susceptible strain. The targets of significantly differentially expressed miRNAs included 122 cytochrome P450s, 49 glutathione S-transferases, 153 ABC transporters, 15 ryanodine receptors, 38 cholinesterases, and 84 UDP-glucuronosyl transferases, their function in diamide resistance were further analyzed. Furthermore, we validated the transcript levels of nine miRNAs after diamide insecticide exposure from wild-type larvae collected from Korea.

This study provides important clues for understanding the possible roles of miRNAs in mediating diamide resistance traits in *S. frugiperda.*

Key words: microRNA, *Spodoptera frugiperda*, diamides, insecticide resistance

PG4

Evaluation of lethal and sublethal effects of methyl benzoate on the generalist predator *Orius laevigatus* (Fieber)

Md Munir Mostafiz[1,3], Hwal-Su Hwang[2], Duck-Oung Jung[2,3] and Kyeong-Yeoll Lee[2,3]
[1]Department of Entomology, Kyungpook National University
[2]Department of Applied Biosciences, Kyungpook National University
[3]Sustainable Agriculture Research Center, Kyungpook National University

Methyl benzoate (MBe) is a relatively new botanical insecticide that occurs naturally as a metabolite in plants. However, the toxicity of MBe against non-target organisms has rarely been investigated. This study investigated the lethal and sublethal effects of MBe on the generalist predator *Orius laevigatus* (Fieber) via different exposure routes. Acute toxicity bioassays conducted on *O. laevigatus* showed that the LC_{50} values of MBe for topical and residual toxicity were 0.73% and 0.94%, respectively, after 24 h of exposure. Importantly, a sublethal concentration of MBe (LC_{30} = 0.51%) did not affect the survival and reproduction of *O. laevigatus*. In addition, prey consumption by *O. laevigatus* under different exposure conditions with varying densities of *Aphis gossypii* (Glover) adults demonstrated a good fit for a Type II functional response. So, the sublethal MBe concentration for *O. laevigatus* is categorized as harmless and may be used in conjunction with this predator species for integrated control of many agricultural insect pests.

Key words: biopesticides, environmentally friendly, integrated pest management, natural enemies, sustainble agriculture

PG5

Effects of orchards' surrounding forests on the populations of *Ricania* sp.

Sunghoon Baek[1], Sung-Won Yoon[2] and Chang-Gyu Park[1]
[1]Department of Agriculture and Fisheries Covergence, Korea National University of Agriculture and Fisheries
[2]Chungnam Agricultural Research and Extension Services

갈색날개매미충은 일반적으로 과원에 인접한 숲에서 밀도를 키워서 과수원에 심각한 경제적 피해를 야기하는 해충으로 알려져 있지만, 이는 아직 증명되지 않았다. 따라서, 이번 연구에서는 밤과 감 과원 내부와 인접 산림 지역 내의 갈색날개매미충 밀도를 갈색날개매미충 발육단계별(월동후 알, 약충, 성충, 월동중인 알) 비교하고, 과원에서 인접 산림 지역으로 거리가 멀어짐에 따라 갈색날개매미충 알의 밀도의 변화를 분석하였다. 갈색날개매미충은 알을 제외하고는 발육단계에 상관없이 밤과 감 과원들에서 일반적으로 과원 내부와 인접 산림 지역에서의 발생량에 있어서 통계적(P <0.05)으로 차이가 없었다. 조사 연도에 따라서 월동알의 경우에는 통계적(P <0.05)으로 인접 산림 지역이 과원 내부보다 밀도가 높은 경우도 있었다. 과원에서 거리에 따른 갈색날개매미충의 알의 밀도 변화를 살펴보면, 과원 인접 지역에서의 경우에는 과원내부와 비슷한 수준의 밀도가 발생하지만, 과원에서 멀어질수록 기하급수적으로 밀도가 감소하는 현상이 밤과 감의 과원 모두에서 뚜렷하게 나타났다. 이러한 현상으로 살펴볼 때, 과원에서 갈색날개매미충에 미치는 인접 산림 지역의 역할은 일시적인 도피와 산란을 위한 임시적인 서식지로 작용하는 것으로 추정된다.

검색어: 갈색날개매미충, 감, 밤, 인접산림, 메타개체군

PG6

Genotyping of the honey bee, *Apis mellifera*, variaties based on the single nucleotide polymorphisms for breeding

Kyungmun Kim, Bo-sun Park, Ju-gyeong Kim, Daegeun Oh, Su-bae Kim, Eun-jin Kang, Dongwon Kim, Olga Frunze and Yong-Soo Choi

Division of apiculture, National Institute of Agricultural Science, RDA, Wan-ju 55365, Republic of Korea

The honey bee, *Apis mellifera*, is an important insect for the beekeeping product and the crop polination. Breeding of the physiologically developed honey bee varieties can be a solution to the decreased honey production and increased affection of the diseases and pests. To distinguish the five honey bee varieties managed in the National Institute of Agricultural Science of Korea we genotyped them based on the single nucleotide polymorphisms (SNPs). 10,000 SNPs that can successfully distinguish the five varieties were selected from the 114,629 filtered honey bee SNPs derived by the genotyping-by-sequencing.

Key words: *Apis mellifera*, SNPs, Breeding, Genotyping-by-sequencing

PG7

Juvenile hormone antagonist activity of carbazomycin A isolated from *Streptomyces*

Dong Hwan Park[1], Jae Young Choi[1], Min Gu Park[1], 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

[2]Department of Agricultural Biotechnology, Seoul National University

Insect growth regulators (IGRs) are insecticides which disrupt the action of insect hormones. These are considered alternatives to conventional insecticides due to their high specificity and low environmental toxicity. In this study, actinomycetes were screened for their IGR activity. Among them, *Streptomyces abikoensis* IMBL-1939 strain showed juvenile hormone antagonist (JHAN) and mosquito larvicidal activities. Carbazomycin A was identified as the main active compound and exhibited high larvicidal activity against mosquito larvae. Carbazomycin A reduced the juvenile hormone-triggered biting behavior and ovary development. Moreover, carbazomycin A down-regulated the transcription of JH-related genes in adult mosquitoes. These results suggested that carbazomycin A could be developed as an eco-friendly insecticide.

Key words: Mosquitoes, Actinomycetes, juvenile hormone antagonist

PG8

Glucose influences cold tolerance in the fall armyworm, *Spodoptera frugiperda*

Gokulanathan Anandapadmanaban and Youngjin Park
Plant Quarantine Technology Center, Animal and Plant Quarantine Agency, Gimcheon 39660, Korea

The fall armyworm (FAW), *Spodoptera frugiperda*, is considered as one of the most destructive and cosmopolitan pests. FAW global expanding is limited by overwintering survival. Trehalose (TRE) and glycerol act as cryoprotectants helping cold tolerance in insects. The trehalase (Treh) is a key enzyme that plays a crucial role in TRE hydrolysis into glucose (Glu) for energy supply. To understanding on the roles of Treh, we mined 3 Treh genes from FAW transcriptome analysis. FAW survival rate at low temperature decreased when Treh genes were down-regulated and Glu concentration in hemolymph decreased post RCH treatment. Our results demonstrate that Glu biosynthesis is closely related with cold tolerance as one of cryoprotectants in FAW.

Key words: *Spodoptera frugiperda*, glucose, rapid cold hardening, trehalase, cryoprotectant

PG9

Designing a Next-generation Window Trap Preserving High quality DNA

Seunghyun Lee[1,2,3], Yunho Yang[4], Minhyeuk Lee[5], Jun-Hyung Tak[4], Ming Bai[1*] and Seunghwan Lee[2,3*]
[1]Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences, Beijing, 100101, People's Republic of China
[2]Research Institute for Agricultural and Life Sciences, Seoul National University, Seoul, 08826, Republic of Korea
[3]Insect Biosystematics Laboratory, Seoul National University, Seoul, 08826, Republic of Korea
[4]Insect Pest Chemical Control Laboratory, Seoul National University, Seoul, 08826, Republic of Korea
[5]Korea National Park Service, Wonju 26466, Republic of Korea

Sampling is one of the most important and fundamental processes in the field biology like systematics, ecology, and evolutionary biology. The window trap has long been proven as one of the most effective standardized methods to collect beetles. However, the DNA quality of samples collected by window trap is usually unusably degraded because of water ingression that dilutes the medium. The water ingression cannot be avoided in the long-term survey, even with the so-called roof system, as the wind blew the rain into the collector or condensation forms dewdrop falls into the collector. The low DNA quality of samples has become a more serious problem in the current genomic era of biology.

In this study, we developed LEE trap, a long-term storable bottom collector for the window trap that almost perfectly preserves sample DNA. Medium in LEE trap does not dilute because water does not go in, barely evaporates, and thus DNA quality of the collected samples can be well-preserved. We assessed PCR success rate and Bioanalyzer analysis of both conventional window trap and LEE trap shows the latter outperforms on preserving DNA quality. The 3D printing template of LEE trap is provided online, allowing it to be downloaded, modified, printed, and launched anywhere in the world for free.

Key words: Window trap, DNA preservation, bioanalyzer, PCR

G1

Recent "lovebug" outbreak in Korea: Identification and species distribution modelling of *Plecia longiforceps* (Diptera: Bibionidae)

Seunghun Jung[1], Sangil Kim[1,2], Jonghwan Choi[1] 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

Plecia longiforceps Duda (Diptera: Bibionidae), originally described from Jiangsu, China, is reported for the first time in Korea. The species of the genus *Plecia* generally occupy the tropical and subtropical regions and their larvae are epigeobionts, feeding on substrate of decomposing plant matter. Some of the soil-dwelling bibionid flies are considered nuisance pests, commonly called "lovebugs," due to their characteristic outbreaks in mating pairs. One of the most famous examples is *Plecia nearctica* Hardy, with its well-documented history of range expansion from Costa Rica to the Southeastern United States along the Gulf Coast. In East Asia, *P. longiforceps* may be in the process of becoming an invasive pest through its range expansion, with the recent introduction into the Ryukyu Islands of Japan. In this study, we identify for the first time the lovebug specimens collected from the 2022 outbreak in Seoul as *P. longiforceps*. An integrative taxonomic study based on morphological examination of male genitalia and mitochondrial cytochrome oxidase *c* subunit I (COI) sequence data of the Korean and Taiwanese specimens confirms this species identification. To evaluate the invasive potential of *P. longiforceps*, we evaluate the potential range expansion in East Asia using Ensemble species distribution modelling.

Key words: Invasive alien species, Korea,new record, *Plecia longiforceps*, species distribution modelling

G2

The analysis of population genetics using GBS and DNA barcodes revealed the origin of differential grasshopper, *Melanoplus differentialis*, in the Republic of Korea

Jiseok Kim[1], Su Ryun Choi[2], Moon Nam[3] and Donghun Kim[1]

[1]Department of Vector Entomology, Kyungpook National University, Sangju, Rep. of Korea

[2]Xenotype Co., LTD, Daejeon, Rep. of Korea

[3]Genomicbase Incorporated, Namyangju, Rep. of Korea

Invasive species are unintentionally introduced into new ecosystems and cause various damage to agricultural environments. The differential grasshopper, *Melanoplus differentialis*, was firstly reported from Onsan port, Ulsan, Korea in 2018. To identify the origin of the *M. differentialis* population in Korea, the genetic characters were analyzed using DNA barcodes and GBS (Genotyping-By-Sequencing) analysis. The differential grasshoppers were collected from Onsan, Korea and North America including eight states in the U.S. and two states in Mexico. The haplotypes and genetic variations among populations in Korea and North America were analyzed by using concatenated mitochondrial genes: NADH dehydrogenase subunit 2 (ND2), mitochondrial cytochrome oxidase subunit I (COI), mitochondrial cytochrome oxidase subunit II (COII), and cytochrome B (CytB) as well as SNPs (single nucleotide polymorphism) obtained from GBS analysis. The populations in North America were mainly divided into Southern and Northeastern U.S. *M. differentialis* individuals in Korea were clustered into one clade, of which three were also grouped with Southern U.S. populations. The analysis based on mitochondrial genes revealed that populations in Mississippi and Mexico were genetically close to the Northeastern U.S. in population. Whereas the analysis using SNPs selected by GBS analysis showed that both populations were closely clustered with populations in the Southern U.S. Taken together, we suggest that the Korea population collected from Ulsan, Korea was introduced from the Southern U.S., including Texas.

Key words: differential grasshopper, DNA barcode, population genetics, GBS, SNPs

G3

Systematic study of the genus *Aulacophoroides* Tao (Hemiptera: Aphididae) in Korean Peninsula with their molecular phylogenetic position

Minho Lee[1,2], Mariusz Kanturski[3], Sora Kim[4] 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]Institute of Biology, Biotechnology and Environmental Protection, Faculty of Natural Sciences, University of Silesia in Katowice, Bankowa 9, 40–007 Katowice, Poland

[4]Lab. of insect phylogenetics and evolution, Department of Plant Protection & Quarantine, Jeonbuk National University, Jeonju, 54896, Republic of Korea

Aulacophoroides Tao, 1976 is the Palearctic Asian genus belonging to the largest tribe Macrosiphini (Hemiptera: Aphididae: Aphidinae). Four valid species are recorded so far and they're associated with *Lespedeza virgata*, *Millettia reticulata*, *Millettia* sp., *Wisteria sinensis* (Fabaceae). To date, only one species of *Aulacophoroides* have been reported in the Korean Peninsula: *Aulacophoroides virgatae* Szelegiewicz, 1979 on *Lespedeza virgate*. (Fabaceae) in North Korea. In this study, we report *Aulacophoroides hoffmanni* (Takahashi, 1937) for the first time in South Korea.

The results of this study additionally include as followings: 1) the taxonomic review of the *Aulacophoroides* in the Korean Peninsula, 2) redescription of the poorly known apterous viviparous female and alate viviparous female and description of the hitherto unknown fundatrix, oviparous female, and male of *A. hoffmanni* for the first time in detail and note on life cycle, 3) the first SEM illustration of the *Aulacophoroides* species, 4) the molecular phylogeny position relationships of the *Aulacophoroides* with a sister group, 5) Discussion of morphology and the host plant association.

Key words: Aphids, new record, review, life cycle, SEM, Phylogeny

G4

How did they fall in love with dead bodies? Transcriptomic analysis of olfactory gene evolution in Calliphoridae and Sarcophagidae (Diptera)

Sangjin Han[1], Sangil Kim[1,2], Seunghun Jung[1] 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

Flies (Order: Diptera) are among the most successful taxa tapping into olfactory information, which enables them to be one of the most abundant detritivores owing to their chemoreceptors in the ecosystem. Among them, it is well-known that adult necrophagous flies, such as blowflies (Calliphoridae) and flesh flies (Sarcophagidae), detect semiochemicals generated in the process of decomposition of living organisms or animal carcasses, and start depositing eggs or hatched larvae immediately. Although it is readily accepted that necrophagous flies depend heavily on olfaction for carrion-seeking, detailed studies regarding underlying molecular mechanisms are lacking. Based on transcriptome data, this study shows that olfactory receptors, which may play a vital role in carrion-seeking, are present in necrophagous flies. Transcriptome annotation and gene tree analysis were conducted to identify putative chemosensory gene families within several species of the families Calliphoridae and Sarcophagidae. Our comparative transcriptomic analysis provides a seminal resource for future studies on the olfaction of necrophagous flies. Such data will be fundamental for testing a hypothesis that the emergence of necrophagy in these flies was primarily driven by the evolution of olfactory genes.

Key words: Calliphoridae, gene annotation, necrophagy, olfactory receptors, Sarcophagidae, transcriptomes

G5

Historical review of the Family Halictidae (Hymenoptera: Apoidea) from Korean Peninsula

Seunghun Jung[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

The family Halictidae, called sweat bees, is one of large family in the superfamily Apoidea (Hymenoptera). Approximately 4000 species within four subfamilies and 79 genera of Halictidae recorded worldwide. In East Asia, 117 species and 318 species have been recorded in Japan and China respectively. In Korean Peninsula, since Hirashima (1957) firstly reported *Lasioglossum occidens* smith, and 74 species belonging to three subfamilies are recorded. In this study, we reviewed Halictidae fauna of Korean Peninsula, with illustrations and general information of this group.

Key words: Taxonomy, History, Korea, Sweat bee

G6

Taxonomy of the Genus *Vollenhovia* (Hymenoptera: Formicidae) in South 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

The genus *Vollenhovia* has been recorded with only two species in South Korea: *Vollenhovia emeryi* and *Vollenhovia nipponica*. However, the body size is the only key to distinguish two species due to the lack of morphological differences. Public cytochrome c oxidase I (COI) sequence data of the genus *Vollenhovia* from NCBI GenBank and BOLD Systems are too short to identify species by only DNA barcoding. In this study, we identified additional morphological characters between both species using samples collected from Japan (Kawanishi, Hyogo) and South Korea (Wonju, Gangwon). Furthermore, an expanded DNA barcoding study with longer COI data was conducted using sequences from NCBI Sequence Read Archive (SRA) and collected samples. As a result, *V. emeryi* and *V. nipponica* were clearly divided into two clades morphologically and genetically, regardless of the collection sites. In addition, we found another morphological type of *Vollenhovia* in South Korea, which is socially parasitic on *V. emeryi*, likewise *V. nipponica*, but is morphologically and genetically distinct from other two Korean *Vollenhovia* species. Unfortunately, the genetic distance in COI barcoding between the morphological type of *Vollenhovia* and *V. nipponica* were insufficient to discriminate them at the species level. Further studies are needed to elucidate the taxonomic implication among Korean *Vollenhovia* species.

Key words: COI, DNA Barcoding, Taxonomy,*Vollenhovia emeryi*, *Vollenhovia nipponica*

G7

First discovery of egg parasitoid of Asian longhorned beetle but their extreme rarity alters future direction of biological control

Duk-Young Park[2], Seunghyun Lee[1,2,3], Il-kwon Kim[4], Xingeng Wang[5], Jian J. Duan[5] and Seunghwan Lee[2,3]

[1]Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences, Beijing, 100101, People's Republic of China

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

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

[4]Division Forest Biodiversity, Korea National Arboretum, Pocheon, Korea

[5]USDA-ARS Beneficial Insects Introduction Research Unit, Newark, DE 19713, USA

Egg parasitoids are arguably one of the most emphasized biological control agent (BCA) types in integrated pest management. Even though many egg parasitoids of most major pest insects from different lineages have been known, some major pest species remain unknown and are still underway to being discovered.

This study covers all the efforts on finding egg parasitoids of one of the most devastating pests, Asian Longhorned Beetle (ALB). Here, we devised a new sentinel log trap and carried out five years of intensive surveys in the natural forests where natural ALB populations dwell to discover the ALB egg parasitoid. During this survey, two ALB egg parasitoid larvae were found but died before pupation. We applied molecular identification using public and de novo data of putative parasitoids but failed to identify the dead larvae to a species level. This study asserts the requirement of discovering alternative BCA, not egg parasitoid, to effectively establish an integrative pest management strategy.

Key words: Asian Longhorned Beetle, Biological control, Chalcidoidea, Molecular identification, Parasitoid.

G8

Morphology and Molecular based Phylogeny of Korean *Chrysis ignita* group (Hymenoptera: Chrysididae)

Minkyu Jeong[1], Rahman Md Mafizur[2,3] and Juil Kim[1,3]

[1]Program of Applied Biology, Division of Bio-resource Sciences, CALS, Kangwon National University
[2]Dept. of Biotechnology and Genetic Engineering, Faculty of Biological Science, Islamic University, Bangladesh
[3]Agriculture and Life Sciences Research Institute Kangwon National University

The *ignita* group is the largest and taxonomically challenging group within the genus *Chrysis*; they exhibit merely similar morphology and adopt a parasitic lifestyle. The morphological characteristics might be contributed to misidentification and inconsistent interpretations of *ignita* group species. Only 12 species of *ignita* group, including misidentified species, were recorded in Korean Peninsula. Here, 33 samples were collected and used for morphologically, molecular identification. Universal primers (COI) and newly designed primers that encoded partial mitochondrial genome nearby D-loop regions (between nd4 and 16S rRNA) were used. In addition, the complete mitochondrial genome of representative, *Chrysis principalis* length was 15,917bp. Compared COI sequences deposited in GenBank based on the sequence homology (100% coverage and identity), we found six species, *C. fulgida, C. impressa, C. angustula, C. longula, C. ignita* and *C. subcoriacea* among all the tested samples. So far, our knowledge, *Chrysis impressa* Schenck, 1856, *Chrysis angustula* Schenck, 1856 and *Chrysis subcoriacea* Linsenmaier, 1959 were recorded for the first time in Korea.

Key words: *C. impressa*, *C. angustula*, *C. subcoriacea*, *C. principalis*, mitochondrial genome

G9

RNA interference of two gut proteins (glycoprotein N and cyclophilin) interferes with TSWV transmission of *Frankliniella occidentalis*

Falguni Khan and Yonggyun Kim

Department of Plant Medicals, Andong National University

Tomato spotted wilt virus (TSWV) is a plant virus and causes massive economic damages on high-valued crops. This virus is transmitted by specific thrips including the western flower thrips, *Frankliniella occidentalis*. TSWV is acquired by the young larval thrips during feeding the infected host plants. In the gut, TSWV infects the gut epithelium through hypothetical receptor(s) and multiplies within the cells. The multiplied TSWV particles are then released to hemocoel to infect the salivary gland for the horizontal transmission to another plant hosts. A previous proposed two gut proteins, glycoprotein (G_N) and cyclophilin (Cyp), as the receptors of the TSWV for the entry of the gut epithelium. These two genes were suppressed in their expressions by feeding their specific double-stranded RNAs. Under these RNA interference (RNAi) conditions, TSWV titers did not increase in the thrips after feeding the virus. Furthermore, immunofluorescence assay showed that the dsRNAi-treated larvae did not show TSWV in the gut. Western blotting supported the decrease of TSWV titers in the RNAi-treated thrips. These results suggest that the two gut proteins are associated with TSWV infection to the thrips' midgut epithelium.

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

G10

Molecular characterization of two dopamine receptors, dopamine receptor (D1) and invertebrate specific D1-like dopamine receptor (InvD1L) in *Haemaphysalis longicornis*

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

Dopamine, as a paracrine and/or autocrine factor, is the most effective biogenic amine that induces tick salivary secretion. The salivary glands of ticks are composed of three types of acini (Type-I/-II/-III), which function in different physiological roles in salivary secretion and production of saliva contents. In particular, type-II and type-III acini play critical roles in salivary secretion. In previous studies, two distinct dopamine receptors, dopamine receptor (D1) and invertebrate specific D1-like dopamine receptor (InvD1L), were highly expressed in type II and III acini and function in collecting saliva via inward fluid transport and expelling collected saliva via pumping/gating, respectively. Putative dopamine receptors of *Haemaphysalis longicornis* were identified by BLAST search against the *H. longicornis* genome. We confirmed the full-length ORF of two distinct dopamine receptors, Haelo-D1 and Haelo-InvD1L, with lengths of 1278 bp (426aa) and 1369 bp (467aa), respectively. Phylogenetic analysis revealed that Haelo-D1 and Haelo-InvD1L were orthologous to D1 and InvD1L of *Ixodes scapularis*. Transcripts of D1 and InvD1L were profiled from different developmental stages, i.e., eggs, larvae, nymph, and adults. The molecular function of two dopamine receptors was analyzed by $Ca^{2+}$and cAMP mobilization assay using a heterologous expression system. Further studies, such as RNA interference (RNAi), are required to expand our knowledge about the physiological function of *H. longicornis* D1 and InvD1L in tick salivary secretion.

Key words: *Haemaphysalis longicornis*, Salivary glands, Dopamine receptor

G11

Effects of Nutritional Environment during Development on Reproductive Success in the fruit fly, *Drosophila melanogaster* (Diptera: Drosophilidae)

Kyeong Woon Min, Taehwan Jang and Kwang Pum Lee
Department of Agriculture Biotechnology, Seoul National University

Environments experienced during development have long-lasting consequences for adult performance and fitness in many animals, including insects. There are two conflicting hypotheses proposed for explaining the role of early development in shaping animal phenotype late in life. “Environmental matching” hypothesis predicts that individuals perform best when adult and developmental environment match. “Silver spoon” hypothesis, on the other hand, expects that fitness is higher in individuals developed under favourable environments regardless of adult environments. In this study, we seek to test these two hypotheses by examining the long-term effects of developmental nutrition on adult reproductive performance (i.e., egg production) in the fruit fly, *Drosophila melanogaster*. No matter whether adult and developmental diets matched or not, female flies raised on protein-enriched larval diets produced more eggs than those raised on protein limited larval diets. This strong effect of developmental nutrition on adult fecundity lasted over the first 5 days of the adulthood, but gradually disappeared as flies started to consume adult diets. Our results show that development under nutritionally favourable environments confers lifelong fitness advantages in *D. melanogaster*, providing support for the silver spoon hypothesis.

Key words: Nutrition, Development, Reproduction, Silver spoon hypothesis, *Drosophila melanogaster*

G12

RNAi-based functional analysis of molting fluid chitinases from the Japanese pine sawyer beetle

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 cuticle degrading-enzymes, including epidermal group I and II chitinases (CHTs). Insect chitinase belongs to family 18 glycosylhydrolase (GH-18) and have been classified into at least eleven groups based on phylogenetic analysis. In this study, we report the physiological functions of the molting fluid chitinases, MaCHT5 (group I) and MaCHT10 (group II), including two alternatively spliced isoforms, MaCHT10a and MaCHT10b, from the Japanese pine sawyer beetle, *Monochamus alternatus*. RNA interference (RNAi) 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. All of these results suggest functional specialization of insect molting fluid chitinase genes.

G13

Different development between *Spodoptera frugiperda* USA and China Populations occurred by Ecdysone related genes

Du-Yeol Choi and Youngjin Park
Plant Quarantine Technology Center, Animal and Plant Quarantine Agency, Gimcheon 39660, Korea

The fall armyworm (FAW), *Spodoptera frugiperda*, is one of important pests because FAW give severe damage to economical crops. In Lab condition, the FAW USA population (Sf-USA) showed fast development compared with China population (Sf-China). We analyzed transcriptome and differentially expressed gene (DEG) to examine this difference between two populations. Totally 21,258 DEGs were observed including insulin like peptide-related genes, juvenile hormone-related genes, and ecdysone-related genes from 12.0 Gb transcripts. Among ecdysone-related genes, five genes as *Shade*, *Ecdysone receptor*, *Ecdysone-inducible protein 74*(*E74*), *E75*, and *E78* were selected and down-regulated in Sf-USA using RNA interference (RNAi). Sf-USA reduced growth rate and fecundity. These results suggest ecdysone is closely related development in *S. frugiperda*.

Key words: *Spodoptera frugiperda*, development, ecdysone, transcriptome, RNA interference,

G14

A promoter mutant of an entomopathogenic *Photorhabdus temperata temperata* in GameXPeptide synthase (*gxpS*) modulates the bacterial virulence against a target insect, *Spodoptera exigua*

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

A depsi pentapeptide called GameXPeptide (GXP), a bacterial secondary metabolite of *Xenorhabdus* and *Photorhabdus*, plays a crucial role in the bacterial pathogenicity by suppressing target insect immunity. A bacterial mutant was generated by replacing the promoter of GXP synthase (*gxpS*) with arabinose-inducible PBAD promoter in *P. temperata temperata*. Expression of *gxpS* in the mutant was modulated by the inducer and assessed by RT-qPCR. The promoter modulation led to changes in GXP production quantified by GC-MS/MS. Without the inducer, the mutant was reduced in its virulence by loss of the immunosuppressive activity against the target insect, *Spodoptera exigua*. In contrast, the over-expression of *gxpS* by the addition of the inducer led to increase the virulence by causing a significant immunosuppression.

Key words: GameXPeptide, *Photorhabdus*, promoter, immunity, virulence

G15

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 wide distribution of LPMO-like proteins in various insect species suggests that these enzymes could be involved in chitin degradation in the cuticle, tracheae and peritrophic matrix during development. However, the physiological functions of insect LPMO-like proteins (LPMO15s) are still undetermined. A phylogenetic analysis indicates that insect LPMO15s could be divided into at least four subgroups. In this study, we investigated the function of subgroup I LPMO15 (TcLPMO15-1) in the red flour beetle, *Tribolium castaneum*. RNAi for *TcLPMO15-1* resulted in lethal arrest of molting at all developmental stages. TEM analyses revealed failure of turnover of chitinous exoskeletal cuticles. These results indicate that TcLPMO15-1 plays a critical role in cuticular chitin degradation, which is essential for completion of insect molting.

G16

In vivo transient expression of a viral silencing suppressor, NSs, derived from tomato spotted wilt virus suppresses RNAi efficiencies of both host and nonhost insects

Chul-Young Kim and Yonggyun Kim
Department of Plant Medicals, Andong National University

Tomato spotted wilt virus (TSWV) is a single-stranded RNA virus and causes a serious plant disease. It is transferred to host plants for horizontal transmission by several thrips including *Frankliniella occidentalis*. Its genome contains a gene called NSs, which acts as a silencing suppressor and plays a crucial role in the pathogenicity by defending host antiviral immunity using RNA interference (RNAi). This study aimed to exploit this functional gene to control insect pests. To this end, the gene was cloned to an eukaryotic expression vector and expressed in different insect species via in vivo expression system (IVES). After feeding the recombinant construct to non-viruliferous *F. occidentalis*, total RNA was extracted along with DNase treatment to remove the recombinant DNA. NSs expression was detected for over 2 days in the thrips. Under this expression of NSs gene, thrips were treated with double stranded RNA specific to vATPase. Control thrips suffered with high mortality due to reduction of *vATPase* expression. However, the IVES-treated thrips were rescued from the dsRNA toxicity by suppressing RNAi efficiency. The recombinant was injected to a lepidopteran *Spodoptera exigua* infected with another RNA virus called iflavirus. NSs was expressed in this insect for > 2 days. Interestingly, the larvae expressing NSs were killed more than the control larvae. In fact, the iflavirus titer was higher in the larvae expressing NSs compared to control larvae. These suggest that NSs acts as a silencing suppressor in insects and would be used for a synergist for RNA pathogens to insect pests.

Key words: TSWV, *Frankliniella occidentalis, Spodoptera exigua*, RNAi, NSs

G17

Characterization and comparative study of lipases from entomopathogenic fungi

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

Lipase is one of the most important enzymes which catalyze the hydrolysis of ester bonds in triacylglycerols between fatty acids and glycerol. Recently, lipase derived from an entomopathogenic fungi, *Cordyceps militaris*, was found to act specifically at position *sn*-1,3 of triacylglycerol. In this study, activities of lipases isolated from entomopathogenic fungi were comparatively investigated and conditions for mass expression using the baculovirus expression system were established. Lipase genes isolated from *C. militaris* (CML) and *Beauveria bassiana* JEF-351 strain (BBL351) were introduced in baculovirus genome. When the hydrolysis efficiency of these lipases were investigated by substrate length, both CML and BBL351 showed the highest activity with p-nitrophenyl butyrate(C4). Also, the lipase activity of BBL351 showed approximately 2-fold higher than that of CML and they both showed higher expression efficiency in High-Five cell than Sf9 cell. These results suggested that lipase from entomopathogenic fungi could be useful in various industry and potential to novel natural source of biocatalysts.

Key words: lipase, entomopathogenic fungi, *Cordyceps militaris*, *Beauveria bassiana*

G18

Transgenerational immune priming in honeybees through heat-killed pathogen cocktail feeding

Yun-Hui Kim[1], Bo-Yeon 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, Busan 49315, Korea.

[2]Department of Agricultural Biology, National Academy of Agricultural Science, Wanju 55365, Korea.

The health of honeybees is essential for the pollination and apiculture. The immune priming is attracting considerable attention as a promising means for the well-being of honeybees. The main pathway of transgenerational immune priming (TGIP) to elicit social immunity in honeybees is the ingested pathogen fragments-vitellogenin (Vg)-nurse´s hypopharyngeal gland axis for the queen and young larvae through royal jelly. In this study, we investigated immune priming of the ingested pathogen fragments-Vg-nurse´s hypopharyngeal gland axis in honeybees to heat-killed pathogen cocktail feeding. Immune priming was analyzed by qPCR with *Vg* and *defensin* genes in the honeybee *Apis mellifera* fed with heat-killed *Paenibacillus larvae* and *Ascosphaera apis*. In cage experiments, the expression level of *Vg* and *defensin* genes was highly induced in the fat body of *A. mellifera* nurse bees fed with a cocktail of *A. apis* (1×10^5) and *P. larvae* (1×10^4) in a 1:0.5 ratio (A+P cocktail). For hive experiments, we supplied pollen bread and honey containing the A+P cocktail to the hive. We found that the expression of *Vg* and *defensin* genes was highly increased in the fat body of *A. mellifera* nurse bees and in the whole body of young larvae in hives. We observed that Vg incorporated with pathogen fragments is highly taken up in the hypopharyngeal gland of *A. mellifera* nurse bees fed with the A+P cocktail, which resulted in an increase of major royal jelly proteins in royal jelly. Moreover, two-day-old *A. mellifera* young larvae in hives were increased resistance to *P. larvae* infection. Thus, our findings demonstrate that the A+P cocktail could be used as a 'bee vaccine' for TGIP.

G19

Transcriptome analysis reveals four novel phospholipase A_2 genes in a lepidopteran insect, *Acrolepiopsis sapporensis*

Md Tafim Hossain Hrithik, Joo-An Hong and Yonggyun Kim
Department of Plant Medicals, Andong National University, Andong 36729, Korea

Phospholipase A_2 (PLA_2) hydrolyzes phospholipids and releases free fatty acids and lysophospholipids. It has many orthologs in diverse organisms and forms a gene superfamily. However, traditionally, the PLA_2s are classified into secretory PLA_2 ($sPLA_2$), Ca^{2+}-dependent cellular PLA_2, and Ca^{2+}-independent cellular PLA_2 ($iPLA_2$). The leek moth, *Acrolepiopsis sapporensis*, gives a significant crop loss to welsh onion in Korea. It transcriptome analysis proposed four AsPLA_2 genes, in which were classified into $sPLA_2$ and $iPLA_2$. These PLA_2s were expressed in all developmental stages and inducible to immune challenge. Enzymatically, the PLA_2 activity was observed in larvae of *A. sapporensis* and inhibited by $sPLA_2$ or $iPLA_2$-specific inhibitors. Furthermore, the PLA_2 activity was susceptible to dithiothreitol (DTT) or ethylene glycol tetra acetic acid (EGTA), suggesting the requirement of disulfide bond and Ca^{2+} for the enzyme activity. Inhibition of PLA_2 activity led to significant immunosuppression. These results indicate that the PLA_2s may play a crucial role in the immune system of *A. sapporensis*.

Key words: PLA_2, *Acrolepiopsis sapporensis*, enzyme, calcium, immune

G20

Analysis of the potential overwintering survival of *Spodoptera frugiperda* in Korea

Matabaro Joseph Malekera[1], Rajendra Acharya[1,2], Sushant Raj Sharma[1] and Kyeong-Yeoll Lee[1]
[1]Department of Applied Biosciences, College of Agriculture and Life Sciences,
[2]Department of Entomology, Kyungpook National University

Potential overwintering survival of the fall armyworm (FAW), *Spodoptera frugiperda* was analyzed in the greenhouse and field conditions of the Daegu campus, Kyungpook National University. The optimum temperature of FAW growth and development was 28 to 30 degree centigrade. However, FAW can overwinter for at least 2 generations from October to March in a greenhouse condition but could only survive from October to December in the field condition. In addition, the thermal tolerance capacity of *S. frugiperda* was compared with that of *S. litura* which is a congeneric species native to Asia. Findings suggest that *S. frugiperda* has a greater thermal (heat and cold) tolerance ability than *S. litura*. This study suggests that the FAW can survive in the winter at the greenhouse condition of Korea and has the potential to become one of the most significant alien invasive pests in Korea.

Key words: *Spodoptera frugiperda*, overwintering, thermal tolerance, climate change

G21

Insecticidal synergy between plant essential oils and chlorfenapyr against Housefly, *Musca domestica* (Diptera: Muscidae)

Junho Yoon[1] and Jun-Hyung Tak[1,2]
[1]Department of Agricultural Biotechnology, Seoul National University
[2]Research Institute of Agricultural and Life Sciences, Seoul National University

Plant essential oils are widely acknowledged for their insecticidal activities and synergistic effects to conventional insecticides, but their insecticidal modes of action and the mechanism of synergy remain less understood. In this study, electrophysiological screenings on the larval central nervous system (CNS) of the common fruitfly, *Drosophila melanogaster*, and the housefly, *Musca domestica*, were conducted to identify the neurophysiological effects of the oils and their major constituents. Several oils changed the firing rate of central motor neurons, and four oils were selected to determine their major active compounds. Thymol and eugenol (31.1% and 87.2% in thyme and clove bud oils, respectively) were inhibitory to the nerve firings rate of the CNS, and exhibited synergistic toxicity to the housefly when blended with a respiratory blocking pyrrole insecticide, chlorfenapyr. On the other hand, *trans*-cinnamaldehyde and terpinen-4-ol (74.6% and 52.0% in cinnamon and teatree oils) were excitatory to the nerves, as displaying antagonistic interaction to chlorfenapyr in their insecticidal activity. Chlorfenapyr led to ATP depletion in the insects, and the inhibitory compounds accelerated the process. On the other hand, neuro-excitatory compounds seemed to nullify the depletion. This was further confirmed with synthetic insecticides, permethrin and chlorpyrifos, as the two compounds showed excitatory nerve firings and antagonistic toxicity. Meanwhile, the synergistic interaction between the inhibitory compounds (thymol and eugenol) and chlorfenapyr was diminished when ATP was artificially injected, indicating that the bioenergetic effects of neuroinhibitors are responsible for their synergistic interactions. Additionally, none of the tested neuroactive compounds exhibited a significant change in electrophysiological response when mixed with chlorfenapyr.

Key words: botanical insecticides; plant essential oils; synergy; chlorfenapyr

G22

Target site and metabolic resistance mechanism in *Spodoptera frugiperda* (Lepidoptera: Noctuidae) against Deltamethrin

Kijung Kwon, Changhee Han and Juil Kim
Program of Applied Biology, Division of Bio-resource Sciences, CALS, Kangwon National University

The fall armyworm, FAW, *S. frugiperda*, is one of the major invasive pest in serial crops that seriously threatens South Korean agricultural production such as corn and food security. Insecticide resistance is one of the nuisance in pest management. As part of an effort to solve these factors, insecticide resistance mechanism was studied using a Pyrethroid, Deltamethrin which are widely used for FAW control. As results, no point mutations (T929I and L1014F) were identified from the target site, *para* type voltage-gated sodium channel which previously reported. Alternatively, there was a significant difference when PBO, a synergist of P450, was treated and non treated, and it was confirmed that P450 was involved in Deltamethrin resistance . However, there was no significant difference in mortality between the DEM and TPP-treated and non-treated groups. Hence, GST and esterase appear to have little involvement in Deltamethrin resistance. Following, transcriptome analysis is in progress to figure out which P450 genes are involved in Deltamethrin resistance.

Key words: FAW, Pyrethroid, DNA mutation, synergistic test, bioassay, RNA seq

G23

Sporulation analysis of *Beauveria bassiana* JEF-350 with high thermotolerance

Yujin Jeong[1], Soeun Park[1], Yeram Im[1], Insoo Jeon[1], Yulim Park[1], Kijung Kim[1], Gahyeon Song[1], Putri Novadhea[1], Hanna Yang[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 and handling cost. However, blastospores are generally unstable to thermal stress. In this study, *Beauveria bassiana* JEF-350 was cultured at different media to produce heat-resistant blastospores. The fungus was cultured in a 250-ml flask containing SDB, SSYP, or YPG liquid medium for seven days. All the fungal cultured showed > 95% mortality against *Thrips palmi*, but SSYP-mediated fungal culture had the highest blastospore productivity and thermotolerance. The SSYP liquid medium is considered an excellent substrate to culture JEF-350. Based on these results, we are analyzing the culture pattern of JEF-350 in a bioreactor containing SSYP or YPG media, and we will establish culture conditions for production of heat-resistant JEF-350 blastospores.

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

G24

Effect of temperature on the flight activity of *Spodoptera frugiperda* (Lepidoptera : Noctuidae)

Heo Jin Woo, Sori Choi, Subin Kim, Seung Yong Hyun and Dong-soon Kim
College of Applied Life Science, SARI, Jeju National University

열대거미나방 *Spodoptera frugiperda* (Lepidoptera: Noctuidae)은 아열대지역에서 주로 서식하고, 분포가 동남아지역과 중국 남부까지 확장되어 편서풍을 타고 우리나라로 날아오는 비래해충으로 알려져 있다. 국내에는 2019년에 처음 비래가 확인된 이후 현재까지도 비래하여 피해를 주고 있다. 현재 열대거세미나방의 비래를 예찰하고 확산을 방지하기 위해 제주 지역 곳곳에 페로몬 트랩을 설치 및 수거하여 포획 상황을 확인하고 있다. 열대거세미나방이 페로몬 트랩에 포획되는 주요 시간대의 온도 조건은 이들이 비행하는 데에 있어 중요하기 때문에 트랩 포획 데이터와 일몰 후 5시간 동안의 온도자료를 분석하여 조사하였다. 또한 실내에서 비행 온도의 한계점을 알아보기 위하여 4℃, 6℃, 8℃, 12℃에서 저온 비행 실험을 진행하였다. 결과적으로 4℃와 6℃에서는 비행할 수 없었으며, 8℃와 12℃에서는 비행하였으나 8℃에서는 약 40초, 12℃에서는 약 1분간의 비행 후부터는 날갯짓은 가능하였으나 회전장치(Mill)을 회전시킬 정도의 비행력은 없었다.

검색어: 열대거세미나방, 저온 비행, 비래해충, 비행 행동, 열대성해충

G25

Life table comparisons and microbiome analysis of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) depending on corn varieties

Jungwon Jeon[1], Jiyeong Shin[2], Kyujin Sa[2], Hwa Yeun Nam[2,3] 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]Incheon International Airport Regional Office, Animal and Plant Quarantine Agency

Fall armyworm (FAW), *Spodoptera frugiperda* is an invasive migratory pest worldwide, that has recently invaded in Korea with damage to economically important crops including corn. Based on the FAW population survey in corn fields, there was a difference in the population depending on the corn variety, so a development comparison was performed based on the feeding preference and the life table according to the corn variety. A total of 6 cultivars of corn (mibaek 2-ho, heukjeom 2-ho, dreamoak, oryun popcorn, oryun 2-ho, and miheukchal) were selected, 3 commercially available waxy corn cultivars, 2 popcorn cultivars, and 1 processing purpose cultivar was selected and used in the experiment. As a result of random choice, there was no cultivar showing a statistically significant preferred by FAW, and the larval period of all tested FAWs was about 20 days. Based on microbiome analysis, *Enterococcus mundtii* accounted for more than 90% of all 6 varieties. Through this study, it was confirmed that there was no significant difference in FAW development and microbiome structure according to the feeding of different corn varieties.

Key words: *Spodoptera frugiperda*, Life table, Microbiome, Host preference, Alpha-diversity

G26

Effect of environmentally-transmitted *Caballeronia insecticola* on predation of host insect, *Riptortus pedestris* (Hemiptera: Alydidae)

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

Beneficial microorganisms play a pivotal role in expanding ecological niches of host insects by altering physiological conditions. These alternation of host can also entail behavioral changes in the host; however, little is known about behavioral effects of symbiosis on host fitness against predation by natural enemies. In this study, we evaluated how *C. insecticola* alter locomotory behavior and activity pattern of bean bug, *R. pedestris*. Also, how altered behavior of the bean bug affects survivorship against predation was investigated by using hunting spider, *Dolomedes sulfureus* (Araneae: Pisauridae). Locomotory behavior of insect was characterized based on horizontal walking movement over 3 hours in relation to symbiont inoculation. In addition, activity pattern of the bean bug, including feeding, resting, and walking, was monitored over 3 days. Finally, symbiotic and apo-symbiotic insects were exposed to *D. sulfureus* and investigated for their predation rates over 5 days in experimental arena.

Key words: ecology, host-microbe interaction, symbiosis, mutualism, insect behavior

G27

Investigation of activity patterns on *Culex pipiens* and *Culex tritaeniorhynchus*

Gi-Hun Kim, Chang-Won Jang, Sun-Ran Cho, Wook-Gyo Lee and Hee-Il Lee
Division of Vectors and Parasitic Diseases, Korea Disease Control and Prevention Agency (KDCA)

우리나라에 서식하고 있는 빨간집모기와 작은빨간집모기는 각각 웨스트나일열과 일본뇌염을 매개하는 모기종이다. 국내에서는 매년 일본뇌염 환자가 발생하고 있는 반면, 웨스트나일열은 국내에서의 발생은 없지만, 해외로부터 유입이 가능한 질병이다. 이러한 두 종에 대한 활동시간대를 확인하기 위해 부산 강서구에 위치한 도심지(공원)와 철새도래지에서 5월부터 9월까지 시간대별(18시~06시)로 활동양상을 조사하였다. 빨간집모기의 경우 5월부터 채집이 되었고, 주 활동시간대(평월기준)가 철새도래지에서는 20시와 06시였으며, 도심지에서는 20시와 05시였다. 작은빨간집모기의 경우 7월부터 채집되었고, 철새도래지에서는 20~6시까지 고르게 활동하였으나, 도심지에서는 20시였다. 두 종에 대한 활동양상을 분석한 결과, 빨간집모기는 온도, 습도, 및 조도의 차이가 급변할 때, 작은빨간집모기는 조도가 없을 때 활동하는 것으로 판단된다. 이 두 종의 활동에 대한 정보를 통해 매개체 방제에 적용할 수 있는 기초 자료로 활용하고자 한다.

검색어: *Culex pipiens*, *Culex tritaeniorhynchus*, 활동양상

G28

Determining high-risk areas for beekeeping in South Korea

Ehsan Rahmi[1] and Chuleui Jung[1,2]
[1]Agricultural Science and Technology Institute, Andong National University, Andong 36729, Republic of Korea
[2]Department of Plant Medical, Andong National University, Korea

In South Korea, there are two native and exotic honeybee species that are reared to produce honey and pollinate agricultural products. One of the challenges of beekeeping in South Korea is the presence of hornet species of the *Vespa* genus, which are known as important enemies of honeybees. Therefore, determining high-risk areas for beekeeping in South Korea will greatly help the country's beekeeping economy. To determine high-risk areas for beekeeping in South Korea, we used species distribution models (SDMs). Using climatic data and presence points, we created nine habitat suitability maps for two honeybees and seven hornet species. Hornets' distribution maps were overlaid to determine high-risk areas for beekeeping. Our results indicated that the potential geographic distribution of two native and exotic honeybee species in South Korea are different from each other. We also fund that each hornet species can potentially occupy certain parts of South Korea. However, the southern parts of Korea that have a subtropical climate are more favorable for hornets to occupy than other regions.

Key words: Honeybees, hornets, SDMs, beekeeping, South Korea

G29

Establishment of optimum conditions for bioassay of *Varroa* mite, *Varroa destructor,* using residual contact vial (RCV) method

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

The *Varroa* mite, *Varroa destructor* is an ectoparasite that feeds on honey bee fat body and is considered as one of the causes of colony collapse disorder . Acaricides such as fluvalinate and coumaphos have been used for a long time to control *Varroa* mites. However, extensive use of acaricides has resulted in the development of acaricide resistance in *Varroa* mites. Therefore, resistance management is crucial for effective *Varroa* mite control. For on-site resistance monitoring, the residual contact vial (RCV) method has been developed. In this study, optimum conditions were evaluated for RCV-based bioassay. After treatment of fluvalinate using RCV, knockdown or dead individuals were sampled at various time point and their resistance genotypes (L925I mutation in the voltage-gated sodium channel) were determined by sequencing The results revealed that susceptible individuals without the mutation were only reliably distinguished from resistant individuals at early time points after treating relatively low doses. Our findings clearly indicated that judicious selection of diagnostic dose and mortality evaluation time is essential for ensuring the accurate bioassay results.

Key words: *Varroa destructor*, resistacne, residual contact vial, condition

G30

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

Yu Lim Park[1], Soeun Park[1], Yeram Im[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 2 days after treatment, some genes related to melanization and Toll signaling pathway are down-regulated, however up-regulated on 4 days after treatment. In conclusion, the immune response was suppressed by ERL836 infection.

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

G31

Acaricidal and insecticidal activity of plant essential oils and constituents derived from Tasmanian pepper essential oil against *Tetranychus urticae* and *Myzus persicae*

Min-Woo Lee[1], Dong-Ho Lee[1], Jae-Woo Lee[1], Il Nam[1], Min-jung Huh[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

Tetranychus urticae and *Myzus persicae* are considered polyphagous pests that damage many plants, and resistance to pesticides is an issue. Therefore, acaricidal and insecticidal activities of 44 plant essential oils (EO) were investigated using the spray method to find promising candidates for controlling mites and aphids. Among 44 plant EO, tasmanian pepper essential oil (TPEO) showed the strongest acaricidal and insecticidal activity against both arthropod pests. TPEO showed 100% and 72% mortality against *T. urticae* and *M. persicae* at 2mg/mL concentration, respectively. Bioassay-guided islation of TPEO by using silica gel column chromatography and gas chromatography-mass spectrometer (GC-MS) identified polygodial as the major active compound. Acaricidal and insecticidal activity of Eungjinssag (EJSG), an organic agricultural material registered for the control of mites and aphids in Republic of Korea, were compared with those of TPEO. The acaricidal and insecticidal activity of TPEO was stronger than that of EJSG against *T. urticae* and *M. persicae* at most test concentrations. This study demonstrates that TPEO is the potential candidate for the control of mites and aphids in field.

Key words: *Tetranychus urticae*, *Myzus persicae*, tasmanian pepper oil, polygodial

G32

Comparison of nematicidal efficacy of emamectin benzoate and abamectin formulations against the pine wood nematode, *Bursaphelenchus xylophilus*

Jong-won Lee[1], Mwamula Abraham Okki[2], Jae-hyuk Choi[1], Ho-wook Lee[1], Yi Seul Kim[2], Min-jae Kim[2] and Dong-Woon Lee[1,2*]

[1]Department of Ecological Science, Kyungpook National University Sangju, Korea
[2]Department of Entomology, Kyungpook National University Sangju, Korea

The pine wilt disease is caused by *Bursaphelenchus xylophilus*. In Korea, abamectin and emamectin benzoate formulations have been used in tree injection to control PWN. In this study, the efficacy of compound formulations were tested. Although the concentration of active ingredient is uniform among all studied formulations, efficacy conformed to 3~4 groups with similar levels of effectiveness. Also, the efficacy of the mixed compound was lower than that of the single compound produced by the same company. It can be concluded that the selection of specific inert ingredients and insecticides by the manufacturers has a bearing on the efficacy of the resultant formulation.

Key words: *Bursaphelenchus xylophilus*, mortality, nematicidal, emamectin benzoate, abamectin

G33

Spatial repellency of essential oils on the Asian tiger mosquitoes and their synergistic interactions

Yujin Kim and Jun-Hyung Tak
Department of Agricultural biotechnology, Seoul National University, Korea

본 연구에서는 흰줄숲모기(*Aedes albopictus*)를 대상으로 31가지 식물 정유에 대한 미량적하시험 및 훈증시험, 공간기피시험을 진행하여 접촉 및 훈증 독성과 공간 기피 효과를 비교해보았다. LD50값과 LC50값, 기피율을 Pearson correlation coefficient을 통해 비교한 결과, LD50값과 LC50값 사이에는 양의 상관관계, LD50값과 기피율, LC50값과 기피율 사이에는 음의 상관관계가 존재한다는 것을 확인할 수 있었다. 또한 살충효과 및 공간 기피 효과가 가장 뛰어난 계피(*Cinnamomum cassia*)를 30가지 식물 정유와 혼합한 결과, 공간 기피 효과가 계피를 단독으로 실험한 결과와 비교했을 때 유의미하게 상승하였다. 그 중 공간 기피 효과가 뛰어난 11가지 식물 정유에서 더듬이를 제거한 흰줄숲모기를 대상으로 공간기피시험을 진행한 결과, 기피율이 유의미하게 차이가 났다. 그러나 앞선 결과와 대조적으로 접촉 독성과 기피율 사이의 직접적인 상관관계는 확인할 수 없었다.

검색어: 흰줄숲모기, 식물 정유, 공간 기피

G34

Genome-wide Diamide resistant linked mutation survey in *Spodoptera exigua* (Lepidoptera: Noctuidae)

Changhee Han[1], Hwayeon Nam[2,3] 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]Incheon Airport regional office, Animal and Plant quarantine Agency, Incheon 22382, Korea

Beet armyworm, *Spodoptera exigua* is lepidopteran pest that polyphagous and agricultural destructive worldwide, To control *S. exigua*, diamide such as chlorantraniliprole have been widely used for more than a decade. However, high level of diamide resistance have been reported last five years in Korea. To elucidate the mechanism of resistance to diamide, two factors were identified: metabolic factors and increased insensitivity to diamide insecticide based on mutations. Metabolic factor was evaluated using the synergists test and RNAseq, and it was confirmed that some of specific cytochrome P450 such as CYP9A40 is involved in the development of resistance. As a result of confirming the mutation in the target site, Ryanodine receptor (RyR), only I4790M mutation was found in the field population as well as extremely high level of diamide resistant strain. However, it does not appear to be involved in the development of high resistance. Because I4790M mutation was found even in old samples which collected before diamide commercialized in Korea (2008). Therefore, after constructing the Korean reference genome data set (ASM1567961v1), in total 19 individual consensus genome sets generated to identified diamide resistant related mutations and/or InDels. These results will be discussed.

Key words: *Spodoptera exigua*, CYP9A40, Ryanodine receptor, Synergistic test, InDel, SNP

G35

Characteristics of insecticidal substances from the entomopathogenic fungus *Metarhizium pinghaense* 15R

InJi Heo[1], Seulki Kim[1], Gui Hwan Han[2], Seonghun Im[2], Jeong Won Kim[2], Dong Young Hwang[1], Ji Won Jang[1], Jin Young Lee[3], Soo Dong Woo[3] and Tae Young Shin[1]
[1]Department of Agricultural Biology, Jeonbuk National University
[2]Center for Industrialization of Agricultural and Livestock Microorganisms
[3]Department of Agricultural Biology, Chungbuk National University

Aphids (Hemiptera: Aphididae) are agricultural pests for a wide range of economically important crops worldwide. Entomopathogenic fungi have been studied and developed as biological agents for various insect pests. Also, their secondary metabolite such as culture filtrate known as insecticidal substance. In this study, characteristics of insecticidal substances of *M. pinghaense* 15R strain culture filtrate showing strong insecticidal activity against cotton aphids were evaluated, and primary data for the development of biochemical pesticides derived from entomopathogenic fungi using insecticidal substances were determined.

Key words: *Metarhizium pinghaense*, entomopathogenic fungus, culture filtrate, insecticidal substance

G36

The improved *Bacillus subtilis* as a biocontrol agent against insects and plant diseases

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

Biocontrol in agriculture is a crucial method for the management of insects and plant diseases. It reduces the use of various synthetic pesticides which cause many harmful effects on the environment. *Bacillus subtilis* (Bs) is known as a biocontrol agent against plant diseases due to its ability to produce a range of antimicrobial compounds such as iturines, fengicines and surfactines. Also, *Bacillus thuringiensis* (Bt) produces δ -endotoxins used to control of insects. This study aimed to construct the dual-functional biocontrol agent against insects and plant fungal diseases by introducing the pMBD-ABC encoding *cry1Ac*, *cry1Be* and *cry1C* Bt insecticidal proteins genes into the Bs strain, which controls the growth of certain plant pathogenic fungi. The improved Bs strain was also evaluated for its insecticidal activities and antifungal activities in this study. These results suggested that the improved Bs strain could be useful for the development of microbiome pesticides which could be applied for simultaneous control of both insects and plant diseases.

Key words: biocontol agent, *Bacillus thuringiensis*, *Bacillus subtilis,* antifungal activity, insecticidal proteins

G37

Larvicidal activities of *Cnidium officinale* Makino root extract and its constituents against *Aedes albopictus*, and development of cellulose nanocrystal-stabilized Pickering emulsion

Jae-Woo Lee[1], Jonghyun Shin[1], Min-Jung Huh[1], Il Nam[1], JiHong Park[1], Dongho Lee[1], Min-Woo Lee[1], Jun-Hyung Tak[2,3], Jinho Hyun[1,3] and Il-Kwon Park[1,3]

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

We investigated the larvicidal activities of 11 herbal plant extracts against the Asian tiger mosquito, *Aedes albopictus*. Among the plant extracts, *Cnidium officinale* root methanol extract (CoRM) showed the most potent larvicidal activity against *Ae. albopictus* presenting 100% of mortality at 0.125 mg/mL concentration, followed by methanol extract of *Syzygium aromaticum* flower bud. CoRM was identified to contain three bioactive phthalides, (*Z*)-ligustilide, cnidilide, and senkyunolide, which showed more than 90% of mortality at 0.05 mg/mL against *Ae. albopictus.* Here, we present the cellulose nanocrystal (CNC)-based Pickering encapsulation method of CoRM, which is not harmful to nature to improve inappropriate properties of the extract, such as high viscosity and low solubility to the water. The CNCs were located at the water-CoRM interfaces because of their amphiphilicity, forming the well-dispersed CoRM droplets in the water. The CNC-stabilized Pickering emulsion of CoRM was analyzed using the phase stability, emulsion size distribution, zeta potential, contact angle, and rheological property. They maintained their colloidal stability until 14 days in the water. In addition, the stable CNC-stabilized Pickering emulsion of CoRM showed the strongest larvicidal activity against *Ae. Albopictus* and presented 100% of mortality at 0.125 mg/mL concentration despite not using ethanol to dissolve CoRM. These studies demonstrate that the CNC-based Pickering encapsulation method can be utilized to encapsulate the plant extract leading to critical advances in agriculture regarding biocompatible mosquito larvae control.

Key words: Cellulose nanocrystal-stabilized Pickering emulsion, *Cnidium officinale*, *Aedes albopictus*, Larvicidal activity

G38

Screening of mycoviral diversity and mycovirus library construction on entomopathogenic fungi in South Korea

Dong Young Hwang, Seulki Kim and Tae Young Shin
Department of Agricultural Biology, Jeonbuk National University, Jeonju, Republic of Korea

Mycoviruses are the special group of viruses that infect filamentous fungi. Most of mycoviruses have cryptic infections or hypovirulence, but some causes hypervirulence. Studies of hypervirulence-related mycoviruses on entomopathogenic fungi have been reported abroad. however, in our knowledge, there is no paper in Korea. In this study, a screening method was established to find fungi harbored double-stranded RNA, and the dsRNA-carried strains isolated in Korea were confirmed . A total of 94 isolates belonging to the genera *Beauveria* (82 isolates), *Metarhizium* (10 isolates) and *Cordyceps* (2 isolates) were screened for the detection of dsRNA. As a result, 8 *Beauveria*, 5 *Metarhizium* and 1 *Cordyceps* isolates showed electrophoretic patterns presumed to be infected with viral dsRNA.

Key words: mycoviruses, double-stranded RNA, *Beauveria, Metarhizium, Cordyceps*

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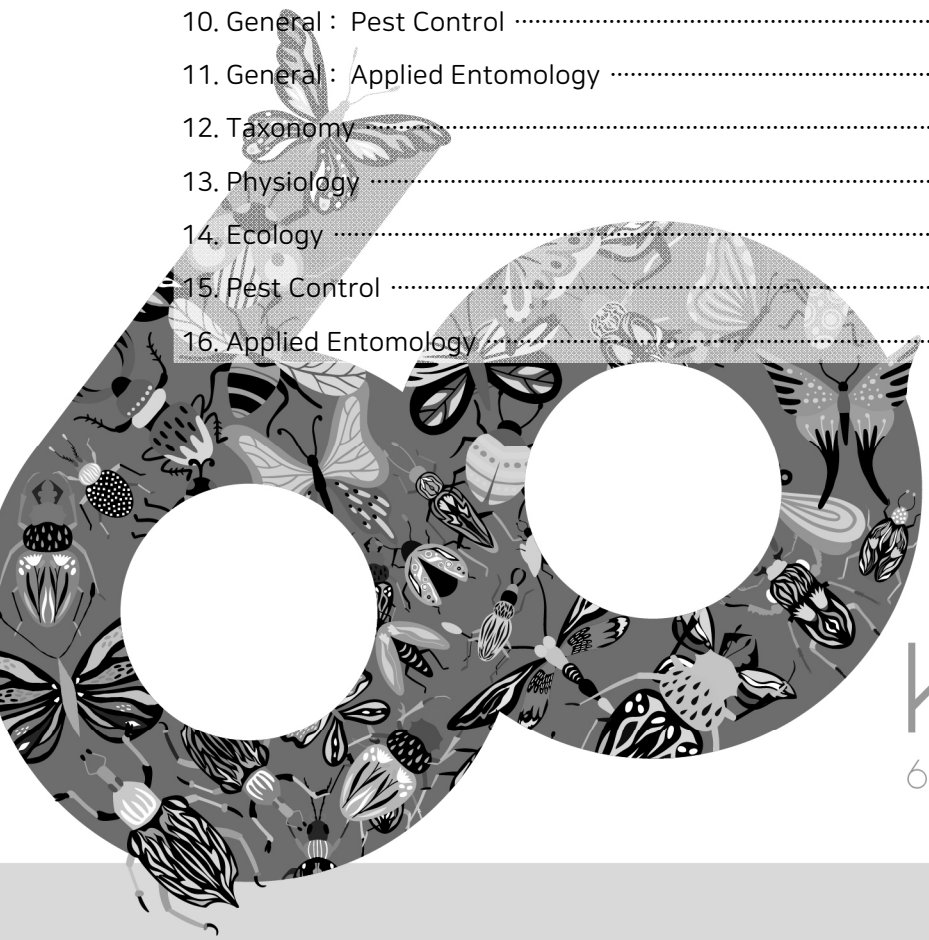

KSAE
60th Anniversary

P1

Survey on invasive exotic ants and the direction of early eradication

Ju Nu Bak[1,2], Kyoung-Yeon Cho[2], Hae Chang Sung[3] and Dong Pyo Lyu[3]
[1]Department of Smart-Farm, Sangji University
[2]K-Invasive Pest Institute
[3]Department of Forest Sciences, Sangji University

세계자연보호연맹이 지정한 세계 100대 악성 침입 외래종 중 하나인 *Solenopsis invicta*(red imported fire ant)가 2017년도 9월 부산 감만 부두에서 처음 발견되어 2022년 9월을 기준으로 총 18회 유입된 적이 있으며 *Linepithema humile*(argentine ant)도 10회 발견되었다. 또한 20~21년 기준 농림축산검역본부의 관리병해충에 속하는 *Paratrechina longicornis*(138회), *Trichomyrmex destructor*(34회), *Solenopsis geminata*(3회), *Monomorium indicum*(5회), *Nylanderia vaga*(2회), *Tapinoma indicum*(1회)은 항만 내에서 백여 차례, 항만 외 내륙에서 몇 차례 발견되었으나 조기 방제하여 아직 내륙 서식 가능성은 희박하다 사료된다. 유령개미(2009년 보고)는 경기지역에 국한된 보고로 남부지역에는 분포하고 있지 않으므로 방제가 이뤄져야 할 관리급 외래 개미로 사료된다. 따라서 관리병해충 중 개미(31종)의 국내 주요 침입로인 무역항만의 정밀 조사를 통해 조사의 방법과 조기 방제에 대한 방향성을 제시하고자 한다.

검색어: 침입외래해충, 정밀조사, 조기방제, 관리병해충

P2

Assessment of internal status of *Prunus yedoensis* as roadside trees injured by *Aromia bungii* (Coleoptera: Cerambycidae)

Byeong Jong Lee, Yun Seop Kim, Seul-Ki Son and Jong Kook Jung*
Department of Forest Environment Protecion, Gangwon National University, Chuncheon 24341, Korea

벚나무사향하늘소(*Aromia bungii* (Faldermann, 1835))는 체리, 살구, 복숭아를 포함하는 *Prunus*속 수목의 중요한 천공성 해충이며, 최근 일본과 유럽으로 침입하여 문제가 되고 있다. 최근 들어 국내에서도 왕벚나무 가로수를 중심으로 피해가 보고되고 있다. 벚나무사향하늘소의 피해는 톱밥 배출, 탈출공 등 외관상 특징으로 구분할 수 있지만, 수목 내부의 상태를 모르기 때문에 벌채를 통한 피해 수목 제거는 거의 이뤄지지 않고 있다. 본 연구에서는 피해목의 내부 상태를 비파괴적인 방법으로 확인하기 위해 실시하였다. 2022년 7~8월 중 가평군과 춘천시에서 왕벚나무 가로수 피해목을 대상으로 톱밥 배출, 탈출공, 수지 분비 등 벚나무사향하늘소에 의한 피해 흔적을 조사하였고, 초음파 단층 촬영(Sonic Tomograph) 방법을 이용하여 수목의 내부 피해 상황을 조사하였다. 조사 결과, 수목 내부의 피해면적은 0-43%의 범위로 확인되었다. 외관상 확인된 피해 정도와 내부의 피해 상태는 정의 상관관계를 보였지만, 일부 수목에서는 부후 피해도 발생한 경우가 있어 벚나무사향하늘소 피해목을 대상으로 더 많은 조사가 요구된다.

검색어: 벚나무사향하늘소, 천공성 해충, 초음파 단층 촬영(Sonic Tomograph)

*본 연구는 한국연구재단(2022R1F1A1059681112218210213010 1)의 지원을 받아 수행하였습니다.

P3

A study on the virulence assay of entomopathogenic fungi against Japanese plum sawfly (*Monocellicampa pruni*)

Hyunwook Jung, Hoe Ri Kim, Hai Nam Nguyen and Se Jin Lee
Department of Agricultural Life Science, Sunchon National University, Korea

Japanese plum sawfly, *Monocellicampa pruni* is a pest that damages plums and was first reported in South Korea in 2018. These pests attacked the fruitlet of plums and caused great damage, especially serious production losses in organic orchards. Herein, we confirmed the possibility of controlling *M. pruni* using entomopathogenic fungi. First, we isolated 6 fungi from infected *M. pruni* and conducted a bioassay to the larva by the spraying method. Result showed that, 6 entomopathogenic fungi showed 80-90% mortality in laboratory conditions. Mycosis was observed on the insect cuticles under high humidity conditions. This work suggests that Japanese plum sawfly can be effectively controlled by entomopathogenic fungi.

Key words: Biological control, *Cordyceps fumosorosea*, entomopathogenic fungi, japanese plum sawfly, pest management

P4

Variation in the cuticular microstructure and its consequence in the coloration in *Cetonia aurata* (Cetoniinae: Scarabaeidae)

Eun Kyo Lee[1], Yewon Yun[2], Hyunsang Yoo[1] and Sang-im Lee[2*]
[1]School of Undergraduate Studies, DGIST, Daegu, Korea
[2]Department of New Biology, DGIST, Daegu, Korea,

Beetle's elytra exhibit a wide range of structural colors which result from variation in the microstructure of the exocuticle. The exocuticle contains helicoidal (bouligand) layers of chitin microfibers, whose arrangement varies both within and among the species. In this study, we aimed to find the correlation between the microstructure of the exocuticle and the characteristics of structural colors of the elytra among the individuals of *Cetonia aurata.* The elytra of *C. aurata* exhibit red, purple, and green iridescence, which can be also viewed as the distinct specular reflectance spectra. This color variation was related with the thickness variation in the helicoidal layers of chitin microfibers. Considering that the depth of exocuticle is beyond the limit where the wavelength of reflected or scattered light can be affected, our results suggest that the intraspecific variation in the microstucture of exocuticle has additional function than the color production.

Key words: structual color, iridescence, exocuticle, beetle, elytra

P5

A new record of *Ecopsocus briggsi* McLachlan, 1899 (Psocoptera: Ectopsocidae) from South Korea

Jae-Yun Kim[1], Ki-Jeong Hong[2] and Wonhoon Lee[1,3]
[1]Department of Plant Medicine, Gyeongsang National University
[2]Department of Plant Medicine, Sunchon National University
[3]Institute of Agriculture & Life Science, Gyeongsang National University

Ecopsocus briggsi McLachlan, 1899 is a worldwide species and has been recorded in Japan, Mongolia, Indonesia, the United States, Chile, South America, Australia, and Europe. We collected *E. briggsi* on Geoje-si, Jinju-si, and Jeju-do in 2022. In this study, *E. briggsi* is reported for the first time in Korea, and ecological photographs and illustrations of diagnostic characters are provided.

Key words: Psocoptera, new record, *Ectopsocus briggsi*, South Korea

P6

Faunistic survey on Lepidopteran insects (Lepidoptera) from Wando Island

Daekyeong Ra[1,2], Hee Han[1,2], Seorin Jeong[1,2], Taewoo Han[1,2], Jinwook Kim[1,3] and Sora Kim[1,3]
[1]Lab. Of Insect Phylogenetics and Evolution, Jeonbuk National University
[2]Department of Agricultural Biology, Jeonbuk National University
[3]Department of Plant Protection & Quarantine, Jeonbuk National University

본 연구는 6월 말과 7월 말에 진행되었던 조사를 통해 채집된 나방 곤충류에 대한 보고이다. 종 동정 결과, 나비목 총 23과(가는나방과, 갈고리나방과, 갈고리좀나방과, 굴벌레나방과, 남방뿔나방과, 명나방과, 밑두리뿔나방과, 박각시과, 밤나방과, 뿔나방과, 산누에나방과, 솔나방과, 원뿔나방과, 잎말이나방과, 자나방과, 재주나방과, 창날개뿔나방과, 큰원뿔나방과, 털날개나방과, 태극나방과, 판날개뿔나방과, 풀명나방과, 통나방과)에 속하는 216종이 확인되었다.

검색어: 완도, 채집조사, 나비목, 종 동정

P7

Effect of entomopathogenic fungus, *Metarhizium* spp., on survivorship of *Ramulus mikado* during summer season in Korea

Dong Gyu Min[1], Seul-Ki Son[1], Min Jeong Baek[2], Sun-Jae Park[2] and Jong Kook Jung[1*]
[1]Department of Forest Environment Protection, Kangwon National University, Chuncheon 24341, Korea
[2]National Institute of Biological Resources, Incheon 22689, Korea

대벌레는 2020년과 2021년에 수도권 일부지역 산림에서 대발생하여 산림해충으로 주목받고 있다. 대벌레류는 녹강균에 의해 치사하는 것으로 보고되고 있는데 국내에서는 연구가 부족한 실정이다. 따라서 본 연구에서는 경기도 의왕시 청계산에서 대벌레를 시기별로 채집하고 14일 동안 실내사육을 하면서 치사율을 조사하였다. 2022년 6월 10일, 6월 24일, 7월 9일, 그리고 7월 22일에 대벌레 약충 또는 성충을 30~40개체 채집하였다. 2주 동안 6월 10일과 6월 24일 채집 개체는 각각 20%와 15%가 치사하였는데, 녹강균은 확인되지 않았다. 이에 비해 7월 9일과 7월 22일 채집 개체는 각각 97.3%와 92.5%가 치사하였으며, 50% 이상의 사체에서 녹강균이 확인되었다. 결론적으로 장마기간이 시작된 6월 23일 이후 고온다습한 환경이 조성되면서 녹강균에 의한 대벌레의 생존기간 감소 현상이 유발된 것으로 판단되며, 이는 향후 대벌레 개체군 크기의 감소에 중요한 역할을 할 것이다.

검색어: 곤충병원성 곰팡이, 녹강균, 생존곡선, 장마, 산림해충, 대발생

*본 연구는 환경부의 재원으로 국립생물자원관의 지원을 받아 수행하였습니다(NIBR202211101).`

P8

Comparison of insect fauna between transgenic rice and common rice in Gyeongsang-do, South Korea

Ji-won Jeong[1], Taechul Park[1], SoEun Eom[1], Kimoon Son[1], Mincheol Kim[1] and Jung-Joon Park[1,2]
[1]Department of Plant Medicine, Gyeongsang National University
[2]Department of Applied Biology, Institute of Agriculture and Life Science, Gyeongsang National University

형질전환작물(Living Genetically Modified Organism; LMO)은 작물 소비자에게 주는 부작용 가능성과 더불어 장기적으로 대상 농업생태계를 서서히 변화시킬 가능성을 내포한다. 따라서 환경 방출과정에서 발생하는 위해성을 생태적 측면에서 평가하고 이에 대한 대책을 마련하기 위해 경남지역에서 연속으로 9년간(2013-2021년), 경북지역에서 3년간(2015년, 2016년, 2020년), 각 7월부터 10월까지 형질전환벼와 일반재배벼에 발생하는 곤충상 변동 양상을 비교하였다. 사천시 형질전환 벼는 경상국립대학교 LMO 격리포장 내에서 재배되었고, 일반벼는 경상남도 사천시에서 재배되었다. 군위군에서 형질전환 벼는 경북대학교 LMO 격리포장 내에서 재배되었고, 일반 벼는 경상북도 군위군에서 재배되었다. 채집방법으로 직접관찰방법인 육안조사 및 포충망 조사와 유인관찰방법인 유아등 트랩 및 끈끈이 트랩을 이용하였다. 직접관찰방법은 실제 실험 포장에서 서식하는 곤충을 채집하며, 유인관찰방법은 주변 다른 지역의 곤충들을 유인하여 채집한다. 그렇기에 직접관찰방법을 중심으로 채집하고, 실험 포장의 종 밀도를 확인하기 위해 부가적으로 유인관찰방법을 사용하는 것이 가장 적합한 것으로 판단된다.

검색어: 형질전환벼, 포충망 조사, 육안조사, 유아등 조사, 끈끈이 트랩

P9

First Record of the Family Olpiidae Banks, 1895 (Arachnida: Pseudoscorpiones) from Korea

Kyung-Hoon Jeong[1] and Seunghwan Lee[2,3]
[1]Department of Applied Biology and Chemistry, Seoul National University
[2]Laboratory of Insect Biosystematics, Department of Agricultural Biotechnology, Seoul National University
[3]Research Institute of Agriculture and Life Sciences, Seoul National University

Olpiidae, which includes 24 genera, and 212 species, is a family of Pseudoscorpiones. Olpiidae distributes in almost every country, including Japan and China. However, seven families were discovered in Korea, except for Olpiidae. We sampled seven specimens of *Nipponogarypus* sp. nov., which is a group of Olpiidae from Ganwoldo. *Nipponogarypus* sp. nov. lives in the supralittoral zone, the second recorded supralittoral species found in Korea, after *Anchigarypus japonicus* (Beier, 1952). Herein, we described a new species, *Nipponogarypus* sp. nov., with the key to the species of Nipponogarypus.

Key words: Pseudoscorpiones, Olpiidae, Nipponogarypus, New record, New species, Taxonomy

P10

Geographical distribution of two reproductive systems for the Asian longhorned tick, *Haemaphysalis longicornis*, in the Republic of Korea

Garyoung Lee[1], Jiseok Kim[2], Seoyul Hwang[2] and Donghun Kim[1,2]
[1]Department of Applied Biology, Kyungpook National University, Sangju, Rep. of Korea
[2]Department of Vector Entomology, Kyungpook National University, Sangju, Rep. of Korea

The Asian longhorned tick, *Haemaphysalis longicornis*, is an obligate ectoparasite transmitting various pathogens, including Severe Fever with Thrombocytopenia Syndrome Virus (SFTSV) and is widely distributed throughout Rep. of Korea. *H. longicornis* reproduces offspring in bisexual or parthenogenesis systems. It is hard to find morphological differences between two reproductive individuals even though their fitness is quite different. In this study, we analyzed the partial sequences of 16s rDNA to see the distribution of bisexual and parthenogenesis individuals of *H. longicornis* collected from nine cities in Korea: Goseong[GS], Sokcho[SC], Ganghwa[GH], Sangju[SJ], Ulsan[US], Yangsan[YS], Jindo[JD], Jeju[JJ], and Seogwipo[SG]. Parthenogenesis individuals dominated northern populations, including Goseong, Sokcho, Ganghwa, and Sangju. Whereas in southern populations, including Yangsan, Jindo, and Jeju, bisexual individuals were dominant. Additionally, the analysis of population genetics using mitochondrial cytochrome B (CytB) revealed that *H. longicornis* population in Korea consists of two major haplotypes (Hap_1 and Hap_3) and are divided into two clades. *H. longicornis* individuals in the Rep. of Korea divided into two reproductive systems, parthenogenesis and bisexual, and the dominant reproductive individuals were different in southern and northern populations. We expected that the present study would provide insights for a better understanding on the vectorial capacity and bacterial community of *H. longicornis*.

Key words: Asian longhorned tick, reproductive system, DNA barcode, population genetics

P11

The effect of temperature on the rate of RSV acquisition in the small brown planthopper, *Laodelphax striatellus*

Kyeongwoo Kim[1], Seoyul Hwang[2] and DonghunKim[1,2]
[1]Department of Applied Biology, Kyungpook National University
[2]Department of Vector Entomology, Kyungpook National University

The small brown planthopper (SBPH, *Laodelphax striatellus*) is a major pest insect found in rice fields. SBPH directly feeds on phloem sap and transmits rice stripe virus (RSV), causing rice stripe disease in temperate and subtropical regions. SBPH is known to migrate from China to the west coast of Republic of Korea, i.e., Seocheon and Gunsan. An increase in average temperature due to climate change will accelerate the emergence of SBPH. In this study, we investigated how different temperatures (24, 27, and 30°C) affect the RSV acquisition capability of SBPH. RSV acquisition rate of SBPH was compared from different developmental stages, i.e., nymphal stages (1^{st} to 5^{th}) and adults. At 27°C, the RSV acquisition rate was the lowest in 1^{st} instar nymphs (45%) and the highest in 4^{th} and 5^{th} instar nymphs (100%). It was suggested that aged SBPH had a higher chance of virus acquisition compared to younger SBPH. Taken together, the rate of RSV acquisition of SBPH varies with temperature and developmental stage.

Key words: *Laodelphax striatellus*, Rice stripe virus

P12

Discovery of Butterflies (Lepidoptera) from Bach Ma National Park in Southern Vietnam

Hee Han[1,2] and Sora Kim[1,3]
[1]Lab. Of Insect phylogenetics and evolution, Jeonbuk National University
[2]Department of Agricultural Biology, Jeonbuk National University
[3]Department of Plant Protection & Quarantine, Jeonbuk National University

Bach Ma 국립공원은 베트남의 남부의 주, 투안티엔 후에(Thua Thien Hue)에 위치한 생태 보호지역이다. Bach Ma 국립공원은 높은 고도와 낮은 고도가 공존하는 지형을 가지고 있으며, 저지대 지역에 비해 고지대 지역은 7도 정도 온도가 낮다. 5월에서 8월 사이에 가장 더운 기후를 나타내며, 하루 동안에도 몇 번이나 바뀌는 기상조건을 갖고 있다. 고도 900m 미만의 열대성 저지대 숲과 900~1,450m 사이 고도의 아열대성 숲이 존재하며 2,000여 종이 넘는 식물이 자생하는 종 다양성 높은 곳으로 알려져 있다. 본 연구는, 7월 초에 진행되었던 조사를 통해 채집된 나비 곤충류에 대한 보고이다. 종 동정 결과, 나비목 4과(호랑나비과, 흰나비과, 부전나비과와 네발나비과)에 속하는 17종으로 확인되었다.

검색어: 베트남, 채집조사, 나비목, 종 동정

P13

Bemisia tabaci biological control using entomopathogenic fungi and efficiency of grain media

Ji Won Jang, InJi Heo, Dong Young Hwang and Tae Young Shin
Department of Agricultural Biology, Jeonbuk National University, Jeonju, Republic of Korea

Whitefly (*Bemisia tabaci*) is an economically significant insect pest to greenhouse plants. They feed on nutrients and indirect damage to the crops as a virus vector. These days biological control with entomopathogenic fungi is a suggested alternative to integrated pest management instead of chemical pesticides. To successfully control pests by using entomopathogenic fungi, not only the pathogenicity of fungi but also mass production is crucial. Therefore, we investigated the effectiveness of spore quantities mass production through different grain media. In this study, we assayed 10 entomopathogenic fungi against *B. tabaci* nymphs and selected the three strains with high virulence. Based on its result, we investigated the production efficiency of selected strains which are millet, Vietnamese rice, and coffee grounds.

Key words: entomoapathogenic fungi, *Bemisia tabaci*, grain media

P14

Macronutrient regulation in the superworm, *Zophobas atratus* (Coleoptera: Tenebrionidae)

Yongsoo Choi[1] and Kwang Pum Lee[2]
[1]Department of Plant Science, Seoul National University
[2]Department of Agriculture Biotechnology, Seoul National University

The larvae of *Zophobas atratus* F. (Coleoptera: Tenebrionidae) are a promising source of dietary protein for animal feed. However, there has been no detailed investigation on macronutrient selection and requirement in *Z. atratus* larvae. Here, we used the geometric framework to explore the behavioural and physiological regulation of protein and carbohydrate in *Z. atratus* larvae. When provided with pairs of nutritionally imbalanced but complementary foods (choice experiment), *Z. atratus* larvae self-composed a diet with a protein-to-carbohydrate (P:C) ratio of 1.47:1 or 1.19:1 throughout the experimental period. When confined to one of six foods imbalanced with respect to P:C ratio (no-choice experiment), *Z. atratus* larvae regulated their protein–carbohydrate intake to form linear intake arrays across nutrient space in a manner similar to those previously described for other nutritional generalists. The nutritional landscapes fitted for larval performance traits exhibited that the performance of *Z. atratus* larvae was maximized at the P:C ratio of 2:1 and fell rapidly as the P:C ratio decreased below 1:1. Our results represent the most comprehensive analysis of macronutrient regulation in *Z. atratus* and have implications for designing an optimal diet for this beneficial insect.

Key words: Beetle, Protein, Carbohydrate, Geometric framework, Nutritional landscape, Nutrient self-selection

P15

Taxonomic study of the genus *Mastax* Fischer von Waldheim, 1828 (Coleoptera: Carabidae: Brachininae) in Korea

Dogyun Han and Sam-kyu Kim
Department of Applied Biology, Kangwon National University, Chuncheon 24341, Korea

The genus *Mastax* Fischer von Waldheim, 1828 (Coleoptera: Carabidae: Brachininae) in Korea is reviewed. Previous Korean record of *Mastax thermarum egorovi* Lafer, 1973 was an error due to misidentification of *Mastax poecila* Schaum, 1863. *Mastax formosana* Dupis, 1912 distributed only in Taiwan is considered a subspecies of *M. poecila*. *M. poecila* is redescribed based on recently collected specimens and added in detail for variation.

Key words: Brachininae, New record, New status, *Mastax*, Variation

P16

Morphological and molecular characteristics of *Sympetrum depressiusculum* (Sélys, 1841) occurring in Korea (Odonata: Libellulidae)

Jee-Young Pyo[1], Sung-Soo Kim[2], Jeong Sun Park[1], Jong-Moon Kim[2], Yang-Keun Song[2], Min Jee Kim[3] and Iksoo Kim[1*]
[1]Department of Applied Biology, Chonnam National University, Republic of Korea
[2]Research Institute for East Asian Environment and Biology, Republic of Korea
[3]Honam Regional Office, Animal and Plant Quarantine Agency, Republic of Korea

Species identity in relationships to geographic boundary of *Sympetrum depressiusculum* (Sélys, 1841) (Odonata, Libellulidae), which is distributed throughout Europe to Korean Peninsula and *S. frequens* (Sélys, 1883), which is endemic to Japan has long been unsettled. Several conflicting opinions are existing: identical one species or independent two species; Korean populations being closer to those of Japan or Europe; and clinal variation among populations of Europe, Korea, and Japan. In this study, we collected a total of 61 individuals from Korea, Japan, Russia, and Netherlands; sequenced for the fragments of *COI*, *16S rRNA*, ITS1, and ITS2; and obtained available sequences of the four regions from public data. Each fragment and concatenated sequences consistently suggest that the divergence of the two species in terms of phylogeny and population genetics is too low or minor.

Key words: Odonata, Dragonfly, *Sympetrum depressiusculum*, *Sympetrum frequens*, *COI*, ITS1, ITS2, *16S rRNA*, Korean Peninsula

P17

Mitochondrial *COI*-based population genetic analysis of the grasshopper, *Patanga japonica* Bolívar, 1898 (Acrididae: Orthoptera), which is a climate-sensitive indicator species in Korea

Jee-Young Pyo[1], Jeong Sun Park[1], Sung-Soo Kim[2], Heon Cheon Jeong[3] and Iksoo Kim[1*]

[1]Department of Applied Biology, Chonnam National University, Republic of Korea

[2]Research Institute for East Asian Environment and Biology, Republic of Korea

[3]Korea Native Animal Resources Utilization Convergence Research Institute, Soonchunhyang University, Republic of Korea

기후온난화에 따른 북위로의 서식처 확장과 이에 따른 집단의 유전적 다양성 변동 특징에 대한 이해는 장기적 측면의 한반도 생물다양성 이해를 위한 초석이라고 할 수 있다. 본 연구에서는 mitochondrial *COI* 유전자의 염기서열을 이용하여 우리나라 100종의 기후변화지표종 중 유일한 메뚜기목 곤충인 각시메뚜기(*Patanga japonica* Bolívar, 1898) 집단(제주도, 담양, 하동, 무안, 밀양, 평택, 영월; 총 125개체)의 유전적 다양성, haplotype 계통, 집단구조 등에 대한 분석을 수행하였다. 그 결과, 북위로의 이동은 가장 빈도가 높은 haplotype만을 동반하며 haplotype 다양성이 감소하는 등 core 집단의 일부 유전적 다양성만을 동반하는 특징을 나타내었다. 이로써 북위의 양질 서식처 유무와 이에 따른 이동집단의 정착 및 활성이 각시메뚜기의 유전적 다양성 회복에 중요한 관건이 될 것으로 사료된다. 아울러 유전체 기반의 연구를 통한 심도있는 결과 도출이 필요한 실정이다.

검색어: 각시메뚜기, 기후변화지표종, 북위이동, 유전적 다양성

P18

Addition of 46 new comoplete mitochondrial genome sequences of the wild silkmoth, *Bombyx mandarina* (Lepidoptera: Baombycidae), from Korea and Japan for population genetic analyses

Jee-Young Pyo[1†], Jeong Sun Park[1†], Min Jee Kim[2], Heon Cheon Jeong[3], Sung-Soo Kim[4], Yutaka Banno[5] and Iksoo Kim[1*]

[1]Department of Applied Biology, Chonnam National University, Republic of Korea
[2]Honam Regional Office, Animal and Plant Quarantine Agency, Republic of Korea
[3]Korea Native Animal Resources Utilization Convergence Research Institute, Soonchunhyang University, Republic of Korea
[4]Research Institute for East Asian Environment and Biology, Republic of Korea
[5]Silkworm Resources Division, Institute of Genetic Resources, Kyushu University, Japan

Bombyx mandarina (Lepidoptera: Bombycidae), the presumed ancestor of *B. mori*, has long been a subject of study to illustrate the geographic relationships, along with the origin of *B. mori*. We report 46 mitochondrial genome (mitogenome) sequences of *B. mandarina* collected from Korea and Japan. Phylogenetic and population genetic analyses strongly showed that all individuals of *B. mandarina* collected in Korean localities formed a strong group together with those originated from northern China and this group was placed as the sister group to *B. mori*. 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, Population structure

[†]These authors contributed equally to this presentation

P19

Efficient control strategy of black stink bug, *Scotinophara lurida* (Burmeister) (Hemiptera: Pentatomidae) in peddy field

Gun-Woo Lee, Yong-Seok Choi, Yoon-Sung Won, In-Soo Hwang and GyeongJu Lee
Chungnam Agricultural Research & Extension Services, Yesan 32418, Korea

친환경 벼 재배면적의 증가로 먹노린재의 발생량이 증가하고 있고 최근에는 일반 관행적 벼 재배지역에서도 먹노린재의 발생량이 꾸준히 증가하고 있다. 화학방제에도 불구하고 먹노린재의 밀도가 꾸준히 증가하고 있어 기존의 방제방법으로는 한계가 있을 것으로 판단되어 효율적인 방제전략을 구축하고자 본 연구를 수행하였다. 먹노린재에 방제효과가 확인된 방제제를 이용하여 포트 검정을 시행한 결과, 낙수 시 80% 이상의 효과를 보인 반면 낙수를 하지 않았을 경우 방제효과는 저조하였다. 이전 연구에서 CDD(누적유효적산온도)를 이용한 2022년도 월동충의 발생을 예측한 결과 2021년에 비하여 활동 시기가 지연될 것으로 나타났고 실제 관측 결과도 동일하였다. 먹노린재 월동충의 활동시기와 벼 재배 농사일정을 고려하여 낙수가 일어나는 시점에 방제를 추진하는 전략을 수립한 결과, 모내기전 5월 월동처 방제 1차, 중간물때기 시기인 6월 중하순 2차 본답방제를 실시할 경우 방제효율이 가장 좋을 것으로 판단되었다.

Key words: 먹노린재, 방제전략, 논

P20

New record of *Bruchidius siliquastri* Delobel (Coleoptera, Chrysomelidae, Bruchinae) in Korea

Yunji Jeong, Kyu-Jin Jeong, Yuri Heo and Ki-Jeong Hong*
Sunchon National University, Suncheon, Korea

Bruchidius siliquastri Delobel, 2007 belongs to the subfamily Bruchinae (Chrysomelidae) supposed an eastern Asian origin, is recently regarded as an invasive species that infests the seeds of the leguminous plant *Cercis siliquastrum* L. (Fabaceae) in Europe. On the other hand, this bruchid species has recently been uploaded by domestic bloggers without precise identification of adult photos in Korea and observed by authors in the spring of 2022 on the *C. chinensis* Bunge planted on the campus of Sunchon National University. In this study, we present new ecological data of a bruchid beetle, *B. siliquastri* Delobel from Korea and suggest that the Korean peninsula should be excluded from East Asia where it is assumed to be the origin.

Key words: Chrysomelidae, Bruchinae, *Bruchidius siliquastri*, *Cercis chinensis*, Korea

P21

Taxonomic study on the monotypic ant genera, *Dacatria* and *Proatta*

Minsoo Dong
Animal Resources Division, National Institute of Biological Resources 42, Hwangyeong-ro, Seo-gu, Incheon 22689, Republic of Korea

The monotypic ant genera *Dacatria* Rigato, 1994 and *Proatta* Forel, 1912 have been drawn attention by many myrmecologists because of the remarkable morphological similarity with Neotropical fungus-growing ants, although it has been revealed that there are no actual distinct relationships. The genus *Dacatria* was originally recorded from Mt. Jirisan, South Korea with a species: *D. templaris*, and the author mentioned the similarity with the genus *Proatta*, which is widely distributed throughout Southeast Asia in the original description. Despite the significant morphological and ecological similarity, and overlapped distribution ranges, there were no approaches discussing the generic positions of these ant genera. After the taxonomical examination using geometric morphometric analysis and phylogenetic study, I suggest that the genus *Dacatria* should be synonymized into *Proatta* based on worker geometric morphometrics, male taxonomy, ecological traits, distribution ranges, and phylogenetic relationships. Photographs of workers and males, phylogenetic relationships, and morphometric relationships of two genera are provided in this study.

Key words: Dacatria, Proatta, formicidae, taxonomy, intergrative taxonomy, geometric morphometrics

P22

First record of the genus *Anaclastoctedon* Plant (Diptera: Empididae) from Korea with a new species

Young-Kun Kim[1] and Sang Jae Suh[1,2]
[1]School of Applied Biosciences, Kyungpook National University
[2]Institute of Plant Medicine, Kyungpook National University

Up to now, only 4 species of the genera *Chelifera* and *Chelipoda* of subfamily Hemerodromiinae are recorded in Korea Fauna. In the course of taxonomic survey on the empidid flies in Korean peninsula, the authors have found a firstly recorded genus *Anaclastoctedon* with a new species *A. koreanum* sp. nov. Morphological characteristics of a newly recorded species are provided here.

Key words: Dance fly, Hemerodromiinae, New species, Taxonomy

* This work was supported by a grant from the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR202231206).

P23

Complete mitochondrial genome of *Aromia bungii* Faldermann, 1835 (Coleoptera: Chrysomeloidea: Cerambycidae) collected in Korea

Sanghyo Park[1], Hyobin Lee[1] and Wonhoon Lee[1,2]
[1]Department of Plant Medicine, Gyeongsang National University
[2]Institute of Agriculture & Life Science, Gyeongsang National University

The red-necked longhorn beetle, *Aromia bungii* is a wood-borer pest of *Prunus* spp.. We determined the complete mitochondrial genome of *A. bungii* collected from the Korean Peninsula. We sequenced the 15,759 bp long complete mitochondrial genome of this species; it comprises a typical set of genes (13 protein-coding genes (PCGs), 2 rRNA genes(rRNAs) and 22 tRNA genes (tRNAs)) and one non-coding region. Phylogenetic trees show that two *A. bungii* mitogenomes were clustered in one clade and are sister to *Xystrocera globosa* within the subfamily Cerambycinae

Key words: *Aromia bungii*, Cerambycidae, Mitochondrial genome, Korea

P24

Two newly recorded species of the Erebidae (Lepidoptera: Noctuoidea) from Korea

Bo Ra Shin[1] and Sei-Woong Choi[2]
[1]Department of Biology, Mokpo National University
[2]Department of Environmental Education, Mokpo National University

The Erebidae are one of most diverse families of Lepidoptera, with over 24,500 described species in about 1,750 genera and 18 subfamilies worldwide. The monophyly of the family was well defined but the phylogenetic relationships at the subfamily level are currently poorly resolved. In Korea, approxiately 500 species of the Erebidae are known, and here we report two additional species, *Sinarella itoi* Owada, 1987 and *Hadennia nakatanii* Owada, 1979 for the first time from South Korea. We provide the diagnosis, description, and the taxonomic position of these species within the Erebidae. This work was supported by a grant from the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR202231206).

Key words: Lepidoptera, Erebidae, *Sinarella itoi*, *Hadennia nakatanii*, new record, Korea

P25

Additional records of Orthothyline plant bug (Hemiptera: Heteroptera: Miridae) in Korea

Minsuk Oh[1,2], WonGun Kim[3], Wonwoong Kim[4] 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
[3]207-404, Dogok Rexle Apt., 221, Seolleung-ro, Gangnam-gu, Seoul, Korea
[4]College of Literature, Science, and the Arts, University of Michigan, Ann Arbor, Michigan, United States of America

Two species of orthotyline plant bugs recognized from the Korean Peninsula including of the first record of *Blepharidopterus angulatus* (Fallén, 1807) and *Ulmica baicalica* (Kulik, 1965). Diagnostic characters of the species are discussed with the illustrations of adult male specimen and genitalic structures. A key to the Korean *Blepharidopterus* and *Ulmica* species are also presented.

Key words: Hemiptera, Miridae, Orthotylinae, *Blepharidopterus*, *Ulmica*, new record.

P26

A New Species of Genus *Conapium* Motschulsky in Korea (Coleoptera, Brentidae: Apioninae)

Yuri Heo and Ki-Jeong Hong*
Sunchon National University, Suncheon, Korea

The genus *Conapium* Motschulsky, 1866 is a genus of the Piezotrachelini tribe, which is diverse in Paleotropics including the Afrotropical and Oriental regions. Although *Conapium* is unknown from the Palaearctic, they are very close to the genera *Protapion* Schilsky, 1908 and *Pseudoprotapion* Ehret, 1990 those have distributed in the western part of the Palaearctic. Recently, a new species, *Conapium koreanum* n. sp., has been found in Korea. This is the first report of the genus in the Palaearctic realm, from the northernmost part of the Northern Hemisphere. We provide DNA and morphological information of new species with a key to the tribe Piezotrachelini in Korean fauna.

Key words: Apioninae, Piezotrachelini, *Conapium*, Korea, new species.

P27

Molecular Phylogeny of the *Coptolabrus smaragdinus* (Coleoptera: Carabidae) from South Korea

Myeonghwan Kim, Eun Young Choi, Jong Bong Choi, Taeyeong Kwon, Myeong Cheol Kim, Hee Soo Lee and JongKyun Park
Department of Ecological Science, Kyungpook National University, Sangju, Republic of Korea

Famliy Carabidae is one of the largest group with more than 40,000 species recorded worldwide. Among this group, many subspecies have been recorded in different regions, often separated by geographical barriers such as valleys, water systems and mountain ranges. This is because species belonging to subtribe Carabina have degraded hindwings and their dispersal rely mainly on walking. Due to these characteristics, there is high intraspecific diversity depending on the region or habitat.

Among them, *Coptolabrus smaragdinus* sspp., has very high intraspecific variation, including ambiguous in morphological characters such as the reproductive genitalia structure, body color, etc., that is mainly used for classification and identification. Therefore, the current study intended to compare and analyze the mitochondrial *COI* by region to confirm the genetic variation according to geographic barriers, and to identify the genetic relevance in the Jeju Island population and inland populations which is geographically isolated area.

Key words: Carabidae, Carabina, *Coptolabrus smaragdinus*, mitochondrial *COI*, Molecular Phylogeny

P28

Taxonomic revision of the tribe Dyschiriini H.J Kolbe, 1880 (Coleoptera: Carabidae) from Korea.

Myeong Cheol Kim, Eun Young Choi, Myeonghwan Kim, Jong Bong Choi, Taeyeong Kwon, Hee Soo Lee and Jong Kyun Park

Department of Ecological Science, Kyungpook National University, Sangju, Republic of Korea.

Tribe Dyschiriini has been recorded with 9 species, 2 subgenera, 1 genus in Korea. This tribe is well known as hygrophilous pedunculate carabid beetle with body length of 1.95 – 7.5mm. They occurs on wetland such as riverside and intertidal zone, etc. Although they are a rather well-studied group, still difficult to identify them because of their very small size body and morphological similarity. In addition, previous studies for this group are poorly known in Korea.

In this study, taxonomic key, photographs of habitus and diagnosis of each species are provided herein.

Key words: Carabidae, Scaritinae, Dyschiriini, taxonomic key, Korea.

P29

A new record of the genus *Kamendaka* Distant (Hemiptera: Fulgoroidea: Derbidae) from the Korean Peninsula with a key to the Korean species

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

The derbid species *Kamendaka annulata* Yang & Wu, 1993 is recognized from the Korean Peninsula for the first time. The morphological information such as diagnosis and redescription of male habitus and genitalia are presented with photographs and a key to the Korean species of genus *Kamendaka* is provided.

Key words: Fulgoromorpha, *Kamendaka annulata*, Kamendakini, Korea, new record

P30

A checklist of the family Coleophoridae in Korea, with two unrecorded species of the genus *Coleophora* Hübner

Jun-Mo Koo, Jin-Ho Na and Soowon Cho
Department of Plant Medicine, Chungbuk National University

The family Coleophoridae is one of the poorly known lepidopteran groups in Korea, with only 35 species known so far. Here we present two unrecorded species of *Coleophora* Hübner, 1822, *C. serinipennella* Christoph, 1872 and *C. uliginosella* Glitz, 1872, as well as a checklist of Korean Coleophoridae. Diagnostic characteristics and photographs of adults and genitalia for the two species are given.

Key words: Microlepidoptera, casebearers, new record, Korean fauna

P31

Review of the Korean species of the genus *Euconnus* Thomson (Coleoptera: Staphylinidae: Scydmaeninae)

Ui-Joung Byeon, Min-Ho Song and Jong-Seok Park
Department of Biological Sciences and Biotechnology, Chungbuk National University

The Scydmaeninae genus, *Euconnus* Thomson, 1859 comprises 37 subgenera approximately 2,500 species worldwide and only four species, *E. impar* Sharp, *E. lijingkei* Franz, *E. rudimentalis* Jałoszyński, and *E. odaesanensis* Hoshina & Park, were known from South Korea. Additional species of the *Euconnus* has not been recorded in South Korea since *E. odaesanensis* Hoshina & Park recorded in 2020. In this study, we discovered two unrecorded species *E. fustiger* (sharp) and *E. dulcis* Sharp. This is the increasing the number of the *Euconnus* species indentified in South Korea to six.

Key words: ant-like stone beetle, unrecorded, taxonomy, South Korea

P32

Two new records of genus *Drabescus* Stål (Hemiptera: Auchenorrhyncha: Cicadellidae) 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 leafhopper genus *Drabescus* Stål is the largest group in the tribe Drabescini of the subfamily Deltocephalinae (Hemiptera: Auchenorrhyncha: Cicadellidae). So far, the genus contains 63 species from Afrotropical, Palaearctic, Oriental and Australian regions.

In this study, two species of the genus *Drabescus* are reported for the first time from Korea. Re-descriptions and photographs of habitus and male genitalia are given. A key to eight species from Korea is also provided.

Key words: Auchenorrhyncha, distribution, Drabescini, identification, morphology

P33

Taxonomic review of the genus *Lachnus* Burmeister, 1835 (Hemiptera: Aphididae) 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]Institute of Biology, Biotechnology and Environmental Protection, Faculty of Natural Sciences, University of Silesia in Katowice, Bankowa 9, 40–007 Katowice, Poland

The Holarctic genus *Lachnus* Burmeister, 1835 comprises about 23 valid species and mostly associated with *Quercus* spp. (Fagaceae). This genus is morphologically distinguished from other Lachnid genera by the alatae having dark pigmented wings. To date, three species of *Lachnus* have been documented in Korea: *Lachnus chosoni* Szelegiewicz, 1975; *L. quercihabitans* (Takahashi, 1924) and *L. tropicalis* (van der Goot, 1916). We report *Lachnus takahashii* Sorin, 1980 on *Quercus* sp. for the first time in Korea and describe the hitherto unknown alatae of *L. chosoni*.

Key words: Aphids, Lachninae, new record, Korean Peninsula

P34

Review of the Genus *Setolebia* Jedlicka, 1941 (Coleoptera: Carabidae: Lebiini) from Korea

Eun Young Choi, Jong Bong Choi, Tae Yeong Kwon and Jong Kyun Park
Department of Ecological Science, Kyungpook National University, Sangju, Republic of Korea

The genus *Setolebia* contains 5 species worldwide and is distributed in North Eastern Asia. In this study, we have recognised the distribution of the genus *Setolebia* from Korean peninsula, based on *S. caligata* (Bates, 1888).

A diagnostic key for related Korean genera, photographs of the species and host information are provided.

Key words: *Setolebia*, Carabidae, Lebiini

P35

The first record of *Pemphigus bursarius* Linnaeus, 1758 (Hemiptera: Aphididnae: Eriosomatinae) in Korea Peninsula

Hyobin Lee[1] and Wonhoon Lee[1,2]
[1]Department of Plant Medicine, Gyeongsang National University
[2]Institute of Agriculture & Life Science, Gyeongsang National University

The genus *Pemphigus* Harting, 1839 is belonging to the subfamily Eriosomatinae (Hemiptera: Aphididae) including over 70 species in the world. The genus is widely distributed in the Holarctic region. Most of the species in this genus form variously shaped galls on the primary host of *Populus* species. Until now, there are few studies about the genus on the morphological taxonomy in Korea. Up to date, two species of the genus have been recorded from Korea. In this study, a total of three species of the genus is revised. Among them, one species *Pemphigus bursarius* Linnaeus, 1758 was recognized for the first time in Korea. We provide a key to the Korean species and redesctiptions in detail.

Key words: Eriosomatinae, gall-forming aphid, *Pemphigus*, Korea

P36

First record of Genus *Bruchophagus* (Hymenoptera: Chalcidoidea: Eurytomidae) in Korea, with three newly recorded species

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 *Bruchophagus* Ashmead, 1888 is a comparatively large group with 168 valid species in the family Eurytomidae. This genus is well known as a major phytophagous group that eats the seed of Fabaceae. In East Asia, each 8 and 13 species are recorded in China and Mongolia, but no records in Korea and Japan.

Here, we report the first record of the genus *Bruchophagus* in Korea, with three newly recorded species. Key to Korean species, diagnoses and photos of diagnostic characteristics are provided.

Key words: Chalcidoidea, Phytophagous, new record, taxonomy

P37

Revealing phylogenetic position of Anoplophilinae (Orthoptera: Rhaphidophoridae) with biogeographic history

Do-Yoon Kim[1], Sangil Kim[1,2], Hojun Song[3] and Seunggwan Shin[1]
[1]School of Biological Sciences, Seoul National University
[2]Museum of Comparative Zoology, Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA, USA
[3]Department of Entomology, Texas A&M University, College Station, TX, USA

Anoplophilinae is an endemic group of Cave crickets (Raphidophoridae) in East Asia, but its phylogenetic position within the family had been controversial. To shed light on the systematic problems, we performed the molecular phylogenetic analysis for the family Raphidophoridae using multi-locus data including all subfamilies for the first time. We reconstructed the phylogenetic position of all subfamilies including Anoplophilinae and suggested new synapomorphies. By biogeography analyses with divergence time estimation, we suggested the narrative hypothesis that the ancestor lineage of Anoplophilinae migrated to America by crossing the Beringia.

Key words: Raphidophoridae, Anoplophilinae, Phylogeny, Biogeography, Beringia

P38

Discovery of a newly recorded species of family Choreutidae (Lepidoptera) in Korea, with an annotated checklist

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

The family Choreutidae is one of the small sized moths, comprising 406 species of 18 genera worldwide. In Korea, in total, 10 species, 5 genera under the family Choreutidae have been known to date. This study is aimed to report a newly recorded species of the family Choreutidae; *Prochoreutis delicata* (Arita, 1976), and provide the checklist of all known species from Korea.

Key words: Choreutidae, *Prochoreutis*, new record, Korea

P39

A newly recorded species of the genus *Bucculatrix* Zeller (Lepidoptera: Bucculatricidae) from Korea

Jae-In Oh, Ji-Young Lee, So-Yeon Kim, Soo-Jeong Park and Bong-Kyu Byun
Department of Biological Science and Biotechnology, Hannam University, Korea

The family Bucculatricidae (Lepidoptera: Gracillarioidea) is one of the small family. Bucculatricidae comprising more than 300 species worldwide (Liu, 2020). In Koera, only two species have been reported to date (Park, 2013; Lee and Jeun, 2022).

In this study, one species *Bucculatrix duanwuia* Liu, 2020 is reported for the first time from Korea. It is very similar to *B. notella* in appearance, but it can be distinguished by the valva with rather widened terminal part and aedeagus with strongly curved apex. It shows the differernt DNA sequence (COI) with each other. Consequence, totally 3 species (Bucculatricidae) are recorded in Korea. All avaulable information, host plants and images of adults and genitalia for species is provided.

Key words: Bucculatricidae, *Bucculatrix*, new record, leaf-miners, Korea

P40

Molecular approach to Korean mosquitoes (Culicidae: Diptera) using rRNA-ITS2 and mtDNA-COI

Woo Jun Bang[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 family Culicidae, commonly referred to as mosquitoes, is one of the earliest-branching lineages in lower Diptera, and it can transmit various diseases through blood-feeding habits. In Korea, the genus *Anopheles* is known as a main vector of malaria in the demilitarized zone (DMZ) and genus *Culex* caused a pandemic of Japanese encephalitis in the 1960s. In addition, *Aedes albopictus*, a potential vector for Zika and dengue virus, is known to be widely distributed across the Korean peninsula. Although the endemic mosquitoes of Korea are spreading worldwide, most studies on the Korean culids have been limited to a few taxa (*Aedes*, *Anopheles* and *Culex* spp.) for devising control measures, with no emphasis on underlying molecular basis. In this study, we designed new primers for 11 genera of Korean mosquitoes between the 5.8S and 28S region of the ribosomal RNA (rRNA) to facilitate species identification and tested the utility of the targeted gene region for phylogenetic analysis. In this study, we generated DNA sequence data of 13 species in six genera, and conducted a phylogenetic analysis of 40 species in 10 genera based on ribosomal ITS2 and mitochondrial COI sequence data available in the NCBI GenBank database. This study represents the first attempt to analyze a molecular phylogeny of Korean mosquitoes using two molecular makers with ecological traits, providing clearer systematic relations than using single mtCOI marker.

Key words: Culicidae, molecular phylogeny, mosquito, ITS2

P41

A taxonomic review of the order Mantodea in Korea based on morphological and molecular characters

Jaeil Shim[1,2] and Jeong-Hun Song[1]
[1]Department of Agricultural Biology, National Institute of Agricultural Sciences
[2]Department of Biology, Chungnam National University

A taxonomic study of Korean Mantodea is present. Eight species [*Amantis nawai* (Shiraki, 1908), *Acromantis japonica* Westwood, 1889, *Mantis religiosa sinica* Bazyluk, 1960, *Statilia maculata* (Thunberg, 1784), *Tenodera angustipennis* Saussure, 1869, *T. sinensis* Saussure, 1871, *Hierodula chinensis* Werner, 1929, *H. patellifera* (Audinet-Serville, 1839)] belonging to six genera in three families are recognized based on morphological and molecular characters. Genetic divergence of *COI* using uncorrected *p*-distance among the eight Mantodea species ranged from 6.3% to 13.1%, while intraspecific divergence ranged from 0% to 0.3%. All eight species were strongly supported as a single lineage on the neighbor-joining tree. Keys, habitus photographs and illustrations of the diagnoses of the species are provided to facilitate identification.

Key words: Mantodea, taxonomy, review, Korea, molecular characters

P42

Morphological characteristics of larval stages in Neocarabi group from South Korea

Taeyeong Kwon, Eun Young Choi, Myeonghwan Kim, Jong Bong Choi, Myeong Cheol Kim, Hee Soo Lee and Jong Kyun Park
Department of Ecological Science, Kyungpook National University, Sangju, Republic of Korea.

In South Korea, a total of 2 genera, 5 species in the division Neocarabi are known. This group is known as a biological indicator that can evaluate forest ecosystems. Among them, *A. changeonleei* and *A. mirabilissimus mirabilissimus* are legally as endangered species, and *A. leechi yooni* has also been confirmed to be like that recently. Morphological studies related to adults of this group are still being actively conducted, while studies on the immature stage of larval stage are poorly known.

In this study, the morphological characteristics, photographs and taxonomic keys of larvae of 5 species belonging to this group are provided.

Key words: Carabidae, endangered species, larva, taxonomy, Korea.

P43

A taxonomic revision of the genus *Macrotomoxia* Pic, 1922 (Coleoptera: Mordellidae: Mordellinae: Mordellini)

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

The genus *Macrotomoxia* Pic, 1922 is one of the most enigmatic genera of the family Mordellidae, and characterized by the unicolor body with brownish setae, eyes with hypocranial extension, maxillary palps with tentacular appendages in male, stout pygidium, and symmetric parameres. Only two species of *Macrotomoxia*, *M. castanea* Pic, 1922 and *M. gardneri* (Blair, 1931), have been reported in the Oriental region. Furthermore, *Higehananomia palpalis* Kôno, 1935 was synonymized to *M. castanea* and the monotypic genus, *Higehananomia* Kôno, 1935 was treated as a junior synonym of *Macrotomoxia* by Horák (1999). However, during examination of Japanese specimens and type series for this genus, the senior synonym of *H. palpalis* turns out to be *M. gardneri*. We revise the synonymy of Horák (1999) and discuss about distributions between both species.

Key words: Taxonomy, Synonym, Coleoptera, Mordellidae, Mordellini, *Macrotomoxia*

P44

Complete Mitochondrial Genome of the Gypsy Moth, *Lymantria dispar* (Lepidoptera: Erebidae)

Inhyeok Han[1], Na Ra Jeong[1] and Wonhoon Lee[1,2]
[1]Department of Plant Medicine, Gyeongsang National University
[2]Institute of Agriculture & Life Science, Gyeongsang National University

The Gypsy moth, *Lymantria dispar* (Linnaeus, 1758) (Lepidoptera: Erebidae) is a serious pest that attacks forest as well as fruit trees. We sequenced the 15,548 bp long complete mitochondrial genome (mitogenome) of this species. It consists of a typical set of genes (13 protein-coding genes, 2 rRNA genes, and 22 tRNA genes) and one major non-coding A + T-rich region. The orientation and gene order of the *L. dispar* mitogenome are identical to that of the ancestral type found in majority of the insects. Phylogenetic analyses using concatenated sequences of 13 PCGs and 2 rRNAs (13,568 bp including gaps) revealed that the *L. dispar* examined in our study, together with other geographical samples of *L. dispar* in a group forming the family Erebidae and consistently supported the monophyly of each family (Erebidae, Euteliidae, Noctuidae, Nolidae and Notodontidae), generally with the highest nodal supports.

Key words: Mitochondrial genome, Lymantria dispar, Erebidae, Republic of Korea

P45

Genetic comparisons of *Spodoptera litura* populations (Lepidoptera: Noctuidae), in South Korea using mitochondrial DNA sequences

Na Ra Jeong[1], Hyeong Su Kim[1], Sang Hyo Park[1], Jun Hyeok Ko[1], Gwan Seok Lee[2] and Wonhoon Lee[1]
[1]Department of Plant Medicine, Institute of Agriculture & Life Science, Gyeongsang National University
[2]Crop Protection Division, National Institute of Agricultural Sciences, RDA

Spodoptera litura Fabricius, 1775 (Lepidoptera: Noctuidae) is a serious crop pest with a long-distance migratory flight. We investigated pattern of occurrence to trace invasion characteristics and genetic divergence using pheromone trap. So far, we analyzed the genetic diversity and the relationships of *S. litura* 11 populations in South Korea using COI sequences. The 11 populations as a result of analyzing the COI sequences for 133 individuals, a total of 7 haplotypes were identified. The genetic divergence between haplotypes ranged from 0.152% to 0.456%. In the F_{ST} results between populations to compare genetic isolation, it was confirmed that there was a meaningful genetic divergence in Seocheon and Anseong.

Key words: *Spodoptera litura*, Population genetic analysis, Mitochondrial DNA, COI

P46

A new species of *Trissemus* Jeannel, 1949 (Coleoptera: Staphylinidae: Pselaphinae) from Korea

Yeon-Jae Choi[1], Sun-Jae Park[2], Seung-Gyu Lee[2] and Jong-Seok Park[1]
[1]Department of Biological Sciences and Biotechnology, Chungbuk National University
[2]Animal Resources Division, National Institute of Biological Resources

The genus *Trissemus* Jeannel is one of the largest genera in the subfamily Pselaphinae. There are 175 species worldwide including 45 Palearctic species. Nine, two, and one species were recorded in Japan, the Russian Far East, and Taiwan, respectively. This genus was first recorded in Korea in 1973 by Löbl with a report of *T. crassipes*. Six subgenera, *Trissemus* Jeannel, *Trissemites* Jeannel, *Trissemellus* Jeannel, *Trissemodes* Jeannel, *Trissemosus* Jeannel, and *Trissemidius* Jeannel are currently known. Three species (*T. alienus* (Sharp), *T. crassipes* (Sharp), and *T. peninsulanus* Nomura and Lee) belonging to the subgenus *Trissemus* are distributed in Korea. In this study, we report a new species represented by four specimens from the Chungbuk National University Insect Collection (CBNUIC). Illustrations of the habitus and diagnostic characters including male genitalia are also provided. The specimens were collected by sifting clay and reed debris around a swamp.

Key words: ant-loving beetle, taxonomy, new species, swamp

P47

A newly recorded species of *Hexencyrtus* Girault (Hymenoptera: Chalcidoidea: Encyrtidae: Encyrtinae) from Korea

Subin Choi[1] and Sunghoon Jung[1,2]
[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 *Hexencyrtus* Girault, 1915 is a comparatively small group with 3 valid species in the world. In this study, we report a new record of *Hexencyrtus* from Korea. The descriptions and photos of diagnostic characters of the species are provided.

Key words: Encyrtid, new record, parasitoid, taxonomy

P48

Complete mitochondrial genome of the carrion beetle, *Necrodes nigricornis* (Coleoptera: Silphidae), which is forensically important for estimating postmortem intervals in decomposed corpses

Man Il Kim[1,2], Jeong Sun Park[2], Chong Min Choung[1], Min Jee Kim[3] and Iksoo Kim[1*]
[1]Forencsic DNA division, National Forensic Service, South Korea
[2]Department of Applied Biology, College of Agriculture & Life Sciences, Chonnam National University, South Korea
[3]Experiment and Analysis Division, Honam Regional Office, Animal and Plant Quarantine Agency, South Korea

The carrion beetle, *Necrodes nigricornis* Harold, 1875 (Coleoptera: Silphidae) is one of the most frequently attracted species to the animal cadavers among Silphidae in Korea. In this study, we present mitogenome characteristics of *N. nigricornis* to increase the genomic data pools of the family Silphidae, which has forensic importance. The full-length circular genome was 18,503 bp. It contained the typical set of 37 metazoan genes. The maximum-likelihood tree revealed the *N. nigricornis* belonging to Silphinae was placed as the sister to congeneric *N. littoralis.* We hope this mitogenome sequences of the carrion beetle become an important baseline information for future studies on phylogeny at various levels of taxonomic diversity.

Key words: Necrodes nigricornis, mitochondrial genome, forensically significant species, phylogeny

P49

Development of diagnostic and prescription technology for fruit insect pests using image information

Hyeong Su Kim[1], Seok Young Son[1] and Wonhoon Lee[2]
[1]Department of Plant Medicine, Gyeongsang National University
[2]Institute of Agriculture & Life Science, Gyeongsang National University

기후변화에 따른 이상고온, 작물 환경변화 등으로 해충 발생 양상이 달라지면서 기존 잠재 해충의 발생 등으로 농작물의 피해 증가와 작물의 생산량 감소가 크게 우려되고 있다. 오늘날 병해충의 신속한 진단과 진단시스템의 구축의 필요성이 요구되고 있으며, 최근 인공지능(AI) 기술을 활용하여 병해충을 진단할 수 있는 기술이 주목받고 있다. 이에, 과수류 해충의 영상진단 이미지를 확보하기 위해 배, 사과, 포도, 감귤, 자두, 매실, 복숭아, 감 8개의 과수류 작물에서 발생하는 주요 해충 24종의 다양한 태별, 피해 기주 등에 대한 영상진단 이미지 17,000매 생성하였다. 생성된 이미지는 영상정보 라벨링 및 검수할 예정이며 추후 28,000매 이상을 확보하고자 한다. 이러한 자료는 딥러닝 기반 영상학습을 통하여 해충 영상 진단 시스템에 활용될 것이다.

검색어: 인공지능, 과수류, 병해충, 진단 시스템

P50

Discovering misidentificated *Nola* sp. (Lepidoptera, Nolidae), new subconscious natural enemy for some gall aphid

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.

For a long time, the East Asiatic nolid moths identified based on especially Japanese literatures. Among them, the genus *Nola* Leach [1815] is one of the most dependent taxon on those references. As a result of our recent study, a *Nola* species discovered as new species. Additionally, this new species host information should be subconscious natural enemy of forest gall aphid.

Key words: Nolinae, host plant, kleptoparasitic moth

P51

A new record of *Habroloma* (*Parahabroloma*) *yuasai* (Coleoptera: Buprestidae), leaf-miner of *Platycarya strobilacea* (Juglandaceae) from Korea, with biological notes

Donguk Kim[1] and Sang Jae Suh[1,2]

[1]School of Applied Biosciences, College of Agricultural and Life Sciences, Kyungpook National University, Daegu 41566

[2]Institute of Plant Medicine, Kyungpook National University, Daegu 41566

Until now, *Habroloma* (*Parahabroloma*) *yuasai* Kurosawa, 1976 which is known as a leaf-miner of *Platycarya strobilacea* has been reported only in Japan. Moreover, neither the descriptions nor photographs of male genitalia were known hitherto, and biological information was less known. In this study, *H.* (*P.*) *yuasai* is reported for the first time from Korea, with the first description and photograph of male genitalia. Also, their biological notes are presented.

Key words: Buprestidae, jewel beetle, *Habroloma*, leaf miner, new record

P52

Taxonomy of the genus *Coenosia* Meigen (Diptera: Muscidae) from Korea

Dong Min Kim[1] and Sang Jae Suh[1,2]
[1]School of Applied Biosciences, Kyungpook National University, Daegu, 41566, Korea
[2]Institute of Plant Medicine, Kyungpook National University, Daegu, 41566, Korea

The genus *Coenosia* Meigen, 1826 known as "hunter fly" is a predatory fly belonging to the family Muscidae. Until now, more than 350 species in this genus are known worldwide, but there are no records in Korea yet. This study contains taxonomic information with the 6 unrecorded *Coenosia* species from Korea and the key to these species.

Key words: hunterfly, *Coenosia*, Muscidae, Diptera, new record, Korea

P53

A new species of the Genus *Diastata* Meigen (Diptera: Diastatidae) from Korea

Dong Min Kim[1], Young-Kun Kim[1] and Sang Jae Suh[1,2]
[1]School of Applied Biosciences, Kyungpook National University, Daegu, 41566, Korea
[2]Institute of Plant Medicine, Kyungpook National University, Daegu, 41566, Korea

The genus *Diastata* Meigen, 1830 is mainly found in the temperate region, and so far, 35 species have been recorded worldwide. In this study, the genus Diastata is reported for the first time in Korean fauna, with a new science species, *Diastata koreana* sp. nov. External photographs, diagnosis as well as taxonomic remarks of this new species and key to Palaeartic spsecies are presented herein.

Key words: new species, *Diastata*, Diastatidae, Diptera, Korea

* This work was supported by a grant from the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR202231206).

P54

A new species of genus *Notodoma* Lacordaire, 1854 (Coleoptera: Histeridae) from Korea

Jinbae Seung[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 *Notodoma* Lacordaire, 1854 is one of small mycophile groups of the histerids. This genus consists of six species worldwidely. Among them, only one species, *Notodoma fungorum* Lewis, 1884, has been reported from Korea. We recognize a new species, *Notodoma jejuensis* sp. nov., from Jeju-Island in this study. Herein, we provide a key to species of Korean *Notodoma* with diagnosis and photographs of adult for a new species.

Key words: Taxonomy, Histeridae, *Notodoma*, New species, Korea

P55

Microsatellite marker development for *Conogethes punctiferalis* and its application to regional populations in Korea

Il Nam[1], Yujeong Park[2], Min-Jung Huh[1], JiHong Park[1], Jae-Woo Lee[1], Min-woo Lee[1], Dongho Lee[1], Kyungjoo Hwang[1], Soungbin Cho[1], Byung-Chan Kim[1] and Il-Kwon Park[1,3]

[1]Department of Agriculture, Forest, and Bioresources College of Agriculture and Life Science, Seoul National University
[2]Tufrgrass & Environment Research Institute Golf Business, Samsung C & T Corporation Resort Group
[3]Research Institute of Agriculture and Life Science, College of Agriculture and Life Sciences, Seoul National University

The yellow peach moth, *Conogethes punctiferalis* (Guénee) (Lepidoptera: Crambidae) is one of the most destructive pests damaging more than 120 host plants. However, a lack of genetic information on this pest has hindered population genomics researches on population genetic structure, diversity, relationship, and gene flow between diverse populations. In this study, we developed 10 microsatellite markers for *C. punctiferalis* using a transcriptome data, which can provide a resolution to determine the various genetic events. The polymorphisms of simple sequence repeats in these markers were investigated among seven regional populations of *C. punctiferalis* and proved to be polymorphic enough to distinguish regional populations. This study presents the first development of microsatellite markers of *C. punctiferalis* using de novo assembly. These microsatellite markers would be a valuable tool for future geographic genetic structure and diversity between diverse populations of *C. punctiferalis*.

Key words: microsatellite marker, population genetics, geographic genetic structure, *Conogethes punctiferalis*

P56

First report of Euderomphalini Shafee, Rizvi and Khan (Hymenoptera: Eulophidae) from South Korea

Jongmin Bae[1,2], Il-kwon Kim[3] 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
[3]Division of Forest Biodiversity, Korea National Arboretum

Euderomphalini Shafee, Rizvi and Khan (Hymenoptera: Eulophidae) is newly recognized from South Korea. In the present study, we report a newly recorded species of the genus *Euderomphale* with description and its figures.

Key words: taxonomy, new record, Chalcidoidea, Entedoninae, the Korean Peninsula

P57

Three new records of the genus *Cosmolaelaps* (Mesostigmata: Laelapidae) in Korea

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 *Cosmolaelaps* is one of the most abundant groups among the family Laelapidae (Acari: Mesostigmata), it contains at least over a hundred species in the world. In Korea, five species of the genus were recorded. They usually live on the surface of the ground, while some of them are strictly associated with Formicidae (Hymenoptera: Formicoidea) and their nest. Although this genus is widely distributed in various habitats, all of them shared the same morphological character “modified dorsal setae”. In this study, line-drawing plates with captured images and a brief diagnosis of *Cosmolaelaps* sp.1 nov., *Cosmolaelaps* sp.2 nov., and *Cosmolaelaps robustochaetes* Ma & Lin, 2009 moreover, key to the Korean species of *Cosmolaelaps* will be provided.

Key words: *Cosmolaelaps*, Laelapidae, Formicidae, New record, Taxonomy

P58

First record of the family Telemidae (Arachnida: Araneae) from Korea

Jong-Hwa Oh[1], Yong-Gun Choi [3] 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
[3]The Korean Institute of Biospeleology

The family Telemidae Fage, 1913 is a tiny (0.9 – 2.2 mm) haplogyne spider, currently containing 104 species in 16 genera worldwide. Most of the species live in caves, usually having six eyes, though some of them are completely eyeless. In this study, new species of the genus *Telema* Simon, 1882 are described from Korea. This species is also the first recorded family from Korea and the first record as an eyeless spider of Korean species. The specimens were collected from Baetishale cave located in Hapcheon-gun (Gyeongsangnam-do). Description of the new species is provided with a diagnosis and microscopic photographs.

Key words: Telemidae, *Telema*, new record, new species, taxonomy, morphology, eyeless

P59

Three new species of the genera *Nossidium* and *Sindosium* (Coleoptera: Ptiliidae: Nossidiinae) from South Korea

Taeyoung Jang and Jong-Seok Park
Department of Biological Sciences and Biotechnology, Chungbuk National University, Cheongju, 28644, Korea

The family Ptiliidae includes approximately 1,000 valid species within approximately 100 genera, but they are one of the most poorly-known coleopteran families in Korea. Ptiliid beetles are readily distinguished from other beetles based on minute body size (usually less than 2 mm long), feather-like hindwings, as well as peculiar setae on antennomeres. They were originally divided into three subfamilies, Acrotrichinae, Cephaloplectinae and Ptiliinae. However, in 2019, Acrotrichinae and Cephaloplectinae moved into the sufamily Ptiliinae and the new subfamily Nossidiinae was described. In subfamily Nossidiinae, only two species of the genus *Nossidium, N. flachi* and *N. pilosellum* are recorded in the palearctic region. In this study, we report three new Nossidiinae-species from Korea for the first time.

Key words: *Nossidium*; *Sindosium*; new species; featherwing beetle; taxonomy.

P60

The microbiome profile of *Culex tritaeniorhynchus* and *Culex orientalis* from the Republic of Korea

Jeong-Hyeon Lee[1,2], Hyun-Woo Kim[3], Hee-Il Lee[3*] and Hyung Wook Kwon[1,2*]
[1]Department of Life Sciences, Incheon National University
[2]Convergence Research Center for Insect Vectors
[3]Division of Vectors and Parasitic Diseases, Korea Disease Control and Prevention Agency

Mosquitoes, the major vectors of arboviruses, are naturally host to diverse microbiome which play an important role in their development, immunity, and vector competence. The composition of the mosquito microbiome is strongly influenced by the environment, particularly depending on the habitat. *Culex tritaeniorhynchus* is main vector for Japanese encephalitis virus transmission. Moreover, recent study revealed that Japanese encephalitis virus is identified from *Culex orientalis*. Using 16S rRNA Illumina sequencing, we investigate the microbial profiles in the adult female *Culex tritaeniorhynchus* and *Culex orientalis* from Korea. We identified 86 bacterial families that were prevalent in the *Culex tritaeniorhynchus* and *Culex orientalis* microbiome. Most abundant bacteria were *Asaia bogorensis* and *Pantoea agglomerans* which are known to affect vector competence. Furthermore, the microbiome profiles of *Culex tritaeniorhynchus* and *Culex orientalis* represent high similarity, and thus *Culex orientalis* may share ecological niche with *Culex tritaeniorhynchus*. Our findings show that mosquitoes have region-specific microbiomes depending on their habitat.

Key words: microbiome, mosquito, vector competence, Japanese encephalitis virus

P61

Molercualr characterization of two acetylcholinesterases from the western flower thrips, *Frankliniella occidentalis*

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

We investigated the molecular properties of two acetylcholinesterases (FoAChE1 and FoAChE2) from the Western flower thrips, *Frankliniella occidentalis*. Polyacrylamide gel electrophoresis in conjunction with western blotting with AChE1- or AChE2-specific antibodies suggested that both FoAChE1 and FoAChE2 exist in membrane anchored forms. In particular, FoAChE2 appears to be present in an amphiphilic form with a glycophosphatidylinositol anchor. The migration pattern of FoAChE2 in the presence of Triton X-100 or phosphatidylinositol-specific phospholipase C resembled with that of the bands in activity stained gel. Taken together, FoAChE2 may be the main enzyme for synaptic transmission. Further investigation of kinetic and inhibitory properties of recombinant FoAChEs expressed by baculovirus expression system in sf9 cells is essential to clearly identify the major form of AChE in western flower thrips.

Key words: Acetylcholinesterase, Western flower thrips, *Frankliniella occidentalis*, Native-PAGE, Activity stanning, Western blot

P62

Labor-specific gene expression profile in the heads of honey bee, *Apis mellifera*, treated with pesticides

YeongHo Kim[1] and Young Ho Kim[1,2]
[1]Department of Ecological Science, Kyungpook National University
[2]Department of Vector Entomology, Kyungpook National University

Honey bee, *Apis mellifera*, is an economically important insect in ecosystem and agriculture, however, a significant decline in their population has been recently reported due to exposure to various pesticides. Pesticides have been reported to negatively affect foraging activities, such as food orientation, navigation, learning, and memory in honey bee. Therefore, in this study, we investigated the expression levels of genes putatively involved in foraging, learning, and memory in the heads of nurse and forager bee exposed to seven insecticides by qRT-PCR. Although the gene expression pattern was different depending on the type of pesticides, pesticides belonging to organophosphate and pyrethroid generally reduced expression levels of the genes, suggesting that foraging activities could be damaged by these pesticides.

Key words: honey bee, pesticide, foraging, learning and memory

P63

Function of *yellow-y* in adult cuticle melanization of *Monochamus alternatus*

Jihwan Han, Jiyun Wi and Mi Young Noh
Department of Forest Resources, Chonnam National University

Cuticle tanning (pigmentation and sclerotization) is an important physiological event in insect development. In this vital metabolism initiated with tyrosine, dopachrome conversion enzymes (DCEs) encoded by the *yellow* genes accelerate significantly melanization reaction. Insect *yellow* is a rapidly evolving gene family generating functionally diverse paralogs. In this study we identified, cloned cDNA and investigated the function of *yellow-y* (*MaY-y*) in adult cuticle melanin-type pigmentation of the Japanese pine sawyer beetle, *Monochamus alternatus*, which is a major vector of the pinewood nematode, *Bursaphelnchus xylophilus* that causes Pine wilt disease. Real-time qPCR revelated that *MaY-y* was sharply induced in day 9 pupae and declined thereafter during late developmental stages. Loss of function of *MaY-y* caused by RNAi had no effect on larval and pupal development. However, the resulting adults exhibited a reddish-brown body wall and elytra as well as bristles instead of a black coloration in the control animals. These results indicate that MaY-y has a critical role in normal black pigmentation of *M. alternatus* adult.

P64

Selection of stable reference genes for qRT-PCR in *Haemaphysalis longicornis*

Ye Eun Park[1], Yeong Ho Kim[2] and Young Ho Kim[1,2*]
[1]Department of Vector Entomology, Kyungpook National University
[2]Department of Ecological Science, Kyungpook National University

The Asian longhorned tick, *Haemaphysalis longicornis*, that is the most important vector of severe fever with thrombocytopenia syndrome virus (SFTSV) is the dominant species of Ixodidae in Korea. Considering its medical importance, to understand the physiology of *H. longicornis*, it is essential to determine the expression of the genes of interest. To analyze gene expression, qRT-PCR has been widely used. However, selection of reliable reference gene across samples of various condition is necessary for the accurate normalization of target gene expression levels. In this study, we analyzed the transcript levels and expression stabilities of five candidate reference genes (*ACT*, *RPP0*, *RPL23*, *TUB*, and *GAPDH*) in *H. longicornis* under different conditions (different collection months, developmental stages, and SFTSV infection status) with various methods (C_q distribution, NormFinder, BestKeeper, geNorm, and RefFinder). Consequently, a single gene between *RPP0* and *RPL23* was determined to be the optimal reference gene in *H. longicornis* under various conditions by comparing expression level of *HSP70* was normalized with candidate reference genes.

Key words: *Haemaphysalis longicornis*, reference gene, quantitative real-time PCR

P65

Relationship between thrips population size and TSWV infection in hot pepper

Eticha Abdisa, Falguni Khan and Yonggyun Kim
Department of Plant Medicals, College of Life Sciences, Andong National University, Andong 36729, Korea

Tomato spotted wilt virus (TSWV) is one of the most serious plant diseases and causes massive economic damage on high value crops. TSWV is transmitted by specific thrips including *Frankliniella occidentalis.* Our previous study showed that *F. occidentalis* exhibits two main peaks in June and September in hot pepper. However, the TSWV infected hot peppers were noticed in April and May. This discrepancy raised a doubt about the coincidence of the thrips and the plant disease. To test this hypothesis, we compared the thrips occurrence with the frequencies of TSWV infected thrips and hot peppers. The TSWV infected thrips occurred mainly earlier than the main thrips peaks in the two fields. Moreover, a specific field did not have any TSWV infected hot peppers even though there were several thrips peaks. From these observations, we suggest out the TSWV infection on hot pepper depends on the frequency of TWSV infected thrips, but not on the thrips density.

Key words: TSWV, *F. occidentalis*, *F. intonsa*, and Hot pepper.

P66

Analysis of the benthic invertebrates community changes responding to climate changes

Dong-Won Shim, Da-Yeong Lee, Dae-Seong Lee and Young-Seuk Park
Department of Biology, Kyung Hee University, Dongdaemun-gu, Seoul 02447, Republic of Korea

Climate change affects the community structure and ecosystem processes. Therefore, predicting how communities will respond to climate change is important for ecosystem management and conservation planning. The community temperature index (CTI) is a good index to estimate changes of the community according to temperature changes because CTI reflects the thermal preferences of the species in community. In this study, we aimed to identify difference of community structure according to CTI and examined environmental variables that affect CTI. Community changes of Ephemeroptera, Tricoptera and Plecoptera according to changes in CTI were investigated and a structural equation model was used to determine the influence of environmental variables on CTI. As a result of the study, the composition of species and functional feeding groups in community varied by the change of the CTI. In the structural equation model, the influence of each environmental variable on the determination of CTI was identified. It will be useful to predict changes in community composition accompanied with climate change.

Key words: community temperature index, structure equation model, climate change, headwater invertebrates

P67

Analysis of length-mass relationship for freshwater macroinvertebrates

Da-Yeong Lee, Dae-Seong Lee and Young-Seuk Park
Department of Biology, Kyung Hee University, Korea

In order to understand energy flow in food web, biomass is required. However, the process takes a lot of time and cost. If biomass can be inferred from the body length, it will be save the effort. We investigated length-mass relationship for freshwater macroinvertebrates using literature study and direct measurement. In addition, equations according to characteristics such as body length of taxa were compared. Total 29 articles were collected. Body length of more than 17 taxa were directly measured and most of them showed that abundance was decreased as length increased or unimodal length-abundance distribution. In direct mass measurement, most taxa were fitted in $M=aL^b$ equation.

Key words: body length,dry mass, biomass, aquatic insect, length-mass regression, body mass estimation, energy flow

P68

Analysis of North Korean research literature on forest insects from 2000 to 2019

Min-Jung Huh, Jae-Woo Lee and Il-Kwon Park
Department of Agriculture, Forestry and Bioresources, College of Agriculture and Life Sciences, Seoul National University

2000~2019년도까지 20년 동안의 북한의 연구보고서를 대상으로 북한 내 산림곤충/ 산림해충과 관련된 문헌을 조사하여 분석하였다. 한국과학기술정보연구원(KISTI)에서 구축한 북한과학기술원문정보 디지털 라이브러리(NKscholar)에 게재된 논문들 중 해당 기간 동안 산림곤충 혹은 산림해충과 관련된 논문을 전수조사 하였다. 이 중 원본을 확인할 수 있는 논문만을 수집한 결과, 총 5개의 자연과학 북한 내 학술지에서 총 71개의 연구논문을 수집하였다. 71개의 연구논문을 대상으로 학술지별, 연도별, 분야별, 주제 곤충/해충별(종, 목) 논문의 동향을 중복 포함하여 분석하였다. 학술지 중에서는 산림과학 학술지에서 가장 많은 산림곤충 관련 논문이 게재되어 있었고 매년 평균 3.9건의 논문이 발표되었다. 분야별로는 곤충 분류와 관련된 논문이 45건으로 가장 많았으며, 방제 분야가 15건, 생태분야가 9건 있었다. 가장 많이 연구된 곤충 목은 나비목 25건이며, 그 다음으로 딱정벌레목 15건, 노린재목 14건으로 많았다. 특히 방제 분야 연구로는 유기합성농약 뿐만 아니라 곤충병원성균과 천적 곤충을 이용한 방제 방법 연구가 주를 이루었다. 북한 내 주요 산림해충 중에는 솔나방(*Dendrolimus spectabilis*)과 관련된 연구가 제일 많았으며, 진긴수염돌드레(북방수염하늘소), 털벌레(미국흰불나방), 긴나무좀류(참긴나무좀속) 등 남한에서 문제되는 산림해충과 유사한 해충 역시 발견되는 것으로 분석되었다.

검색어: 북한 산림 곤충, 진긴수염돌드레, 털벌레, 산림과학

P69

Geographic distribution and genetic diversity of the invasive fall armyworm, *Spodoptera frugiperda* in Nepal

Sushant Raj Sharma[1], **Rajendra Acharya**[1,2] **and Kyeong-Yeoll Lee** [1]
[1]Department of Applied Biosciences, Kyungpook National University
[2]Department of Entomology, Kyungpook National University

Since 2016, the fall armyworm (FAW), *Spodoptera frugiperda*, has been invaded into most African and Asian countries, causing significant losses to various crop plants such as corns. In Nepal, it was firstly recorded on 9th May 2019, from the southern part and spread all over the country within the year. We analyzed the geographic distribution of invaded populations collected from different locations in Nepal and genetic variation using the triose phosphate isomerase (*Tpi*) gene sequences. The analysis of the fourth exon and intron region of *Tpi* gene sequences revealed that all the samples were the corn strain but not the rice strain, and identified at least three subgroups, *Tpi*-Ca1, *Tpi*-Ca2a and *Tpi*-Ca2b. Among the three subgroups, *Tpi*-Ca1 was most prevalent in Nepal consisting of 87% of all the samples. Our study provides useful information on the genetic diversity of fall armyworms in Nepal.

Key words: *Spodeptera frugiperda*, invasion, *Tpi* gene, corn strain, genetic diversity

P70

Relationship among the temerature, the density of insect pest and damage of host plant: case study of whitefly in tomato greenhouse

Kimoon Son[1], Taechul Park[1], SoEun Eom[1], Ji-won Jeong[1], Mincheol Kim[1] and Jung-joon Park[1,2]
[1]Department of Plant Medicine, Gyeongsang National University, Korea
[2]Institute of Agriculture and Life Science, Gyeongsang National University, Korea

Insect pest causes to damage to the host plant and changes the health of the plant as the density fluctuates. Insects are sensitive to environmental factors including temperature and humidity to maintain energy and moisture balance, Among them, temperature change affects the activity and reproduction of insects. Thus, the optimal temperature would be shown the higher density of insect pest, and the more severe damage to the host plants. In this study, the experiment is conducted to measure the difference in damage to the greenhouse tomatoes according to the density of *Bemisia tabaci*, in different growing season (*i.e*. different temperature of atmosphere). This study aims to analysis the difference in damage of host plant and then, analysis of causal relationship among the temperature, the density of insect pest and damage of host plant.

Key words: insect pest density, temperature, plant health, *Bemisia tabaci*, greenhouse tomatoes

P71

Population dynamics of ticks (Acari: Ixodidae) and their SFTS virus-harboring rates from 2019 to 2021 in Gyeonggi-do, South Korea

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

Ticks are the medically important vectors which transmit diseases to human including Severe Fever with Thrombocytopenia Syndrome (SFTS). Given that there is no vaccine for SFTS currently available, prevention of SFTS is important and this can be achieved by monitoring the SFTS virus vectors. Therefore, this study reports the results of three-year field survey using CO_2 bait traps to characterize the species composition of the SFTS-vector ticks and their seasonal abundance in diverse landscapes. In addition, the minimum infection rate (MIR) of SFTS virus in the ticks was estimated. From the field survey, *Haemaphysalis longicornis* Neumann was the most dominant species. With regard to seasonal population dynamics, *H. longicornis* nymphs peaked in spring and adults peaked subsequently in summer. In addition, the MIR of SFTS virus was highest in 2020 yielding 0.96 and no SFTS virus was detected in 2021.

Key words: Asian longhorned tick, monitoring, tick-borne disease, MIR

P72

Biological control of ragweed requires timing: Field tests by the ragweed leaf beetle

Seokbin Kim[1] and Youngsung Joo[1,2]
[1]Department of Biological Sciences and Biotechnology, Chungbuk National University
[2]Department of Biology, Chungbuk National University

Ambrosia artemisiifolia L. (common ragweed) is a globally invasive, allergenic, troublesome weed. Korean rural areas are also inundated with ragweed. Ragweed leaf beetle, *Ophraella communa,* has been tested as a biological control agent for ragweed, but its effective release timing and density not been investigated in Korea. The effectiveness of biological control by the ragweed leaf beetle in controlling ragweed in the field can only be proven if an environment for controlling insects has been created. For herbivore exclusion experiments, we built twelve greenhouses measuring 4m x 4m which were covered with insect-proof nets of 20-40 mesh. This led us to conduct an experiment to measure the control efficiency based on the densities of the beetle and developmental stages of ragweed in the field. Young ragweeds are susceptible to the beetle attack, demonstrating the importance of early control.

Key words: plant ontogeny, herbivore density, field test, insect-proof net greenhouse

This work was carried out with the support of "Cooperative Research Program for Agriculture Science and Technology Development (Project No. PJ013476012022)" Rural Development Administration, Republic of Korea.

P73

Effects of six soybean cultivars on development and reproduction of bean bug, *Riptortus pedestris* and *Halyomorpha halys*

Seong Bin Park[1], Seung-Ju Seok[1], DongHyun Kang[1], Hyunkyung Kim[1], Hyun-Na Koo[1], Hwijong Yi[2] and Gil-Hah Kim[1]
[1]Department of Plant Medicine, Chungbuk National University
[2]Department of Southern Area Crop Science, National Institute of Crop Science, RDA

재배되고 있는 6개 품종의 콩으로 톱다리개미허리노린재와 썩덩나무노린재의 발육, 생존율 그리고 산란수에 미치는 영향과 개체군의 생명표를 작성하였다. 톱다리개미허리노린재의 발육기간은 대풍 2호와 풍산나물에서 짧았고 선풍에서 가장 길었다. 썩덩나무노린재도 풍산나물에서 가장 짧았고 대찬에서 가장 길었다. 생존율은 두 종 모두 대풍 2호에서 가장 낮았고 풍산나물에서 가장 높았다. 성충수명과 산란수도 두 노린재 모두 풍산나물에서 가장 길고 많았으며, 대풍 2호에서 가장 짧고 적었다. 생명표 분석에서 순증가율(R_0)과 내적증가율(r_m)은 풍산나물에서 가장 높았고 대풍 2호에서 가장 낮았다. 이상의 결과에서 대풍 2호가 가장 내충성을 띄는 것으로 나타났다.

검색어: 썩덩나무노린재, 톱다리개미허리노린재, 발육기간, 산란수, 생명표

P74

Feeding behavior and infestation of bean bugs, *Riptortus pedestris* and *Halyomorpha halys* on different soybean cultivars

Seong Bin Park[1], Yeolgyu Kang[1], DongHyun Kang[1], Hyunkyung Kim[1], Hyun-Na Koo[1], Hwijong Yi[2] and Gil-Hah Kim[1]

[1]Department of Plant Medicine, Chungbuk National University

[2]Department of Southern Area Crop Science, National Institute of Crop Science, RDA

To understand the feeding behaviour of *Riptortus pedestris* and *Halyomorpha halys*, stylet penetration behaviour was studied on six soybean cultivars with an Electropenetrography (EPG) system and created the waveforms for both species. Infestation and damaging natures were examined in the soybean fields. The present study reports three EPG waveforms relative to both bug species: NP (non-penetration), Pb (phloem feeding: E1-Salivation and E2-Sap feeding), and G (xylem feeding). The waveforms NP, Pb, and G varied significantly among soybean cultivars. The NP was the shortest in the Pungsannamul and the longest in the Daepung 2ho. The feeding waveforms Pb and G were the longest in the Pungsannamul and the shortest in Daepung 2-ho. In the soybean field, the proportions of damage B- and C-type were highest in the Pungsannamul and the lowest in Daepung 2ho. This study provides perceptive information to understand the feeding behaviour, and field occurrence and damaging patterns of *R. pedestris* and *H. halys*, which may have key implications for the management of hemipteran pests via determining the specificity and susceptibility of host plants.

Key words: electrical penetration graph, soybean bugs, seed damage

P75

Comparison of endosymbiotic bacteria profiles of various whitefly species collected in Korea

Olha Muzhanovska, Hwal-Su Hwang and Kyeong-Yeoll Lee

Department of Applied Biosciences, Kyungpook National University

Whiteflies are phloem-feeding pest insects distributed worldwide. They possess multiple endosymbiotic bacteria which affect various biological characteristics of whiteflies such as development, resistance against environmental stress and pesticides, and efficiency of plant virus transmission. We compared the profiles of 5 secondary endosymbionts [*Arsenophonus* (A), *Cardinium* (C), *Hamiltonella* (H), *Rickettsia* (R), *Wolbachia* (W)] from several whitefly species in Korea. *Bemisia tabaci* is a species complex consisting of various cryptic species. MED/Q1 which is the dominant group in Korea, possessed C, H, R, while MED/Q2 had A, C, R. MEAM1 possessed H, R, W, but JpL had A, C, W. *Bemisia afer* possessed A, C, R. The boxtree whitefly *Aleuroclava hikosanensis* had C, H, R but *Trialeurodes vaporariorum* possessed C, R. The endosymbiont profiles were highly various from each species, even in different strains of MED cryptic species. These results suggest that the relationship between endosymbionts and whiteflies is highly specific in each genetically different groups of whiteflies.

Key words: Bemisia, cryptic species, endosymbionts, vector insects, whitefly

P76

A platform design for the Korean Species Distribution Model (K-SDM) System

Yun Seomoon[1], Dong-Myoung Kim[2], Young-Seuk Park[3], Yang-Seop Bae[4], Seunghwan Lee[5], Jong Kyun Park[6] and Bong-Kyu Byun[2]

[1]IDEAINFO Co., Ltd.

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

[3]Department of Biology, Kyung Hee University, Seoul, Korea

[4]Division of Life Sciences, Incheon National University, Incheon, Korea

[5]Department of Agricultural Biotechnology, Seoul National University, Seoul, Korea

[6]College of Ecology and Environmental Science, Kyungpook National University, Sangju, Korea

최근 기후변화로 인한 외래 곤충의 돌발발생 가능성이 높아지면서(Bale, 2002) 이들의 확산 및 변화예측 진단을 통한 조기방제의 중요성이 대두되고 있다. 유입된 외래 해충의 경우 대부분 유충 및 약충으로 발견되며, 기초생태 및 기주식물 등의 정보가 미비하여 초기대응 및 방제에 어려움을 겪는 경우가 대부분이다. 따라서, 국내에 유입된 외래 해충의 대한 체계적인 데이터 확보를 통해 이들의 정착, 확산, 생태계 영향 예측모델 개발 및 활용시스템의 구축이 절실히 요구되는 실정이다. 본 연구를 통해 K-SDM(Korean Species Distribution Model) 시스템을 구축하여 국내 침입 외래 곤충 및 외래 해충의 조사데이터 확보 및 활용서비스 제공기반을 마련하고자 시스템 구성을 제안한다. 본 플랫폼은 각 참여기관 실무자 및 일반인용 2가지 버전으로 구축될 예정이며, 관리자용 페이지에서는 앱(App) 또는 웹(Web)을 통한 조사데이터 등록 또는 조건 선택에 따른 DB목록 출력 등의 기능이 가능토록 하고, 일반 방문자들에게는 국내 외래 곤충의 현 양상 및 차후 예측정보를 제공할 것으로 기대된다.

검색어: 외래곤충, 외래해충, 분포조사, 침입종, DB시스템

P77

Monitoring of invasive species, *Leptoglossus occidentalis* Heidemann (Hemiptera, Coreidae) of Province Chungcheong and Jeolla, Korea in 2021

Dong-Myoung Kim[1], Da-Som Kim[2], Ji-Young Lee[1], So-Yeon Kim[1], Soo-Jeong Park[1], Jin-Sung Kweon[1], Sang-Yoon Kim[1], June-Hyeok Jeong[1], Jae-In Oh[1], Jun-Min Seo[1] and Bong-Kyu Byun[1]

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

[2]National Science Museum, Daejeon, Korea

최근 기후변화와 발달된 교통수단 등으로 인한 외래해충의 침입이 우리나라의 생태계 교란을 유발하며 생물다양성에 큰 위협이 되고 있다. 또한 외래해충은 새로운 지역으로의 유입 및 확산이 가속화되며 대발생 가능성이 높아지는 추세이다(Bale, 2002). 소나무허리노린재는 북미 원산으로 빠르게 전 세계적으로 전파되고 있는 산림해충으로 2010년 가을 이전에 한국에 유입된 것으로 보고된 바 있다(Yoon, 2012). 본 종의 기주식물은 전체 소나무과 식물로 알려져 있으며 소나무류, 가문비나무류 및 낙엽송 등 광범위한 기주분포를 나타내고 있다(Mariann, 2006; Manastryrski, 2010). 따라서, 침입외래해충의 집중적인 연구와 모니터링은 매우 중요한 과제라 할 수 있다. 본 연구는 전형적인 흡즙성 해충이며 국내 침입외래해충으로 알려져 있는 소나무허리노린재를 대상으로 충청 및 전라지역에서의 발생분포를 확인코자 수행되었다. 이를 위해 2021년 3월부터 10월까지 충청·전라권 주요 행정구역을 중심으로 소나무허리노린재 발생여부를 조사하였다. 조사결과 총 2개 지역 6개소에서 발생여부를 확인하였다.

검색어: 외래해충, 모니터링, 소나무허리노린재, 채집조사, 분포

P78

The Occurrence of Mites in 3 Grape varieties in ChungCheongbuk-do

Myungkyu Song[1], Yeuseok Kwon[1], Jeongmoon Cha[1], Changwon Jeong[1], Eunjin So[1], Seokho Lee[1], InJae Kim[1] and Gilha Kim[2]

[1]Chungcheongbuk-do Agricultural Research & Extension Services

[2]College of Agriculture, Life & Environment Sciences, Chungbuk National University

청포도인 샤인머스켓은 2022년 5,241ha(38.9%) 재배면적을 차지할 정도로 인기가 높은 품종이며, 캠벨얼리는 4,397ha(32.7%)이지만, 과거 우리나라에서 가장 많이 재배했던 품종이다. 또한 충랑은 2018년에 품종등록된 3배체 포도로 신품종 연구가 필요한 품종이다. 2022년 충북의 샤인머스켓 5농가, 캠벨얼리 5농가, 충랑 5농가 포도원에서 응애류 발생생태를 조사한 결과 샤인머스켓은 8월 초 42.2마리/잎, 캠벨얼리는 6월 초 2마리/잎, 충랑은 6월 말 8.7마리/잎의 최고밀도를 보였다. 응애 방제를 위해 샤인머스켓 포도원에서는 0~9회의 살비제를 살포하였고, 캠벨얼리와 충랑은 0~1회 살비제를 살포하였다. 품종별 응애 발생밀도의 차이는 샤인머스켓 잎은 다른 품종과 달리 잎 뒷면에 잎털이 많아 응애 은신이 쉽고, 약제 방제시 잎털에 의해 닿지 않는 경우가 발생해 방제가 어렵기 때문이며, 그에 비해 캠벨얼리와 충랑의 잎 뒷면에 털이 적어 응애의 은신처를 제공하지 않기 때문으로 판단된다. 또한 샤인머스켓 포도잎이 연하여 흡즙성 곤충의 구기가 잎을 뚫을 수 있기 때문으로 사료된다.

검색어: 포도, 응애, 품종, 발생, 밀도

P79

Insects community survey as an environmental indicator of agricultural ecosystem in Jeju Island

Ji-Won Kang[1], Kwang-Lai Park[2] and Jong-Seok Park[1]

[1]Department of Biological Sciences and Biotechnology, Chungbuk National University, 1, Chungdae-ro, Seowon-gu, Cheongju-si, Chungcheongbuk-do 28644, Republic of Korea

[2]National Institute of Agricultural Sciences Oraganic Agriculture Division, Department of Agricultural Environment 166, Nongsaengmyeong-ro, wanju-gun, jeollabuk-do, 55365, Republic of Korea

In the agricultural ecosystem, various types of environments are formed by many variables such as crop type, farming method, and location. In conventional farmland, chemicals are artificially added for the purpose of increasing the yield while decreasing pest populations, which directly affects the ecosystem. It is clear that these side effects pose many problems in terms of sustainable agriculture and biodiversity conservation. In this study, six representative crops in Jeju Island were selected (i.e., sweet corn, pumpkin, sesame, islnd starwort, bean and proso millet) and classified into organic and conventional farmlands, Then, insects were set as environmental indicators to analyze changes in each insect community. Redundancy analysis (RDA) was used to integrate the different variables and insects investigated. In this study, the difference in insect diversity and community structure between crop types in conventional agriculture and organic agriculture is indicated and suggested the potential of organic farming for biodiversity.

Key words: Agricultural ecosystem, Biodiversity, RDA, Sustainable agriculture

P80

Development of models for egg hatching and first instar dispersal of *Ramulus irregulariterdentatus* (Phasmida: Phasmatidae)

Min-Jung Kim, Keonhee E. Kim, Lee Junkee, Yonghwan Park and Youngwoo Nam

Forest Entomology and Pathology Division, National Institute of Forest Science

The stick insect, *Ramulus irregulariterdentatus*, is a native species to Korea and is sometimes considered as a forest pest due to its occasional mass occurrence. It overwinters as egg stage in the soil and polyphagous first instar climbs up to its host trees in the spring season. For realistic phenological prediction which could be helpful for its management, experiments on temperature- dependent development for eggs of laboratory population were performed under three constant temperatures to improve previously reported phenology models. The development times of overwintered eggs collected from the field were also compared by sampling periods, and the emergence and dispersal of the first instar were monitored in three mountainous regions. The starting point when the eggs are under the affection of effective temperature was determined by semi-field experimental data based on the results of the development experiment. There was good agreement between the developed phenology model and the emergence of the first instar in the field. Finally, optimal management time in degree days was suggested based on observed nymphal dispersal.

Key words: stick insect, egg hatch, first instar, dispersal

P81

Temperature-dependent development model and Seasonal occurrence of *Pseudococcus comstocki* (Hemiptera: Pseudococcidae)

Jaekun Kim[1,2], Hong Hyun Park[1], Minjae Kong[1], Kwang-Ho Kim[1], Sung-wook Jeon[1], Yong Hong[2], Kyoung-Wha Kwon[1] and Sun-I Song[1]

[1]Crop Protection Division, National Institute of Agricultural Sciences, RDA.

[2]Department of Agriculture Biology, College of Agriculture & Life Science, Jeonbuk University

The *Pseudococcus comstocki* has been known as a pest that could cause damages to pears, apples, and citrus. However, there is a lack of information on ecological characteristics and spraying timing on the pest. We conducted a temperature-dependent development experiments for the nymphs under five temperature conditions and monitored density changes in four pear orchards using sex pheromone trap during 2022. As a result, the lower threshold temperature was 10.9℃ and the effective accumulated temperature was 333.3DD of the nymphs. Occurrence data showed that the earliest occurrence date of the adult was on April 27 in Naju, May 17 in Wanju, May 20 in Cheonan, May 23 in Hwaseong, and the peak occurrence date was June 24, June 11, June 12, and June 13, respectively.

Key words: *Pseudococcus comstocki*, lower threshold temperature, effective accumulated temperature

P82

Relationship between secondary metabolites of Kimchi cabbage and fitness of Diamondback moth

Jongbu Lim, Gisuk Lee and Sang-Gyu Kim

Laboratory for Ecology, Department of Biological Sciences, KAIST

Plutella xylostella, known as diamondback moth (DBM), is one of the most destructive pests of brassicaceae crops including *Brassica rapa subsp. pekinensis*, known as Kimchi cabbage. Kimchi cabbage have Glucosinolates (GSLs) as their primary defensive metabolites. Despite the economic importance, how GSLs of Kimchi cabbage affect DBM fitness was largely unknown. Here, we measured the fitness of DBM on 8 different cultivars of Kimchi cabbage by life table parameters. Life table parameters are useful in that they represent population growth rate. 10 GSLs and 3 stress phytohormones of each cultivar were measured by Ultra high performance liquid chromatography – Triple quadruple mass spectometry (UHPLC-TQMS) system. The relevance of all data was calculated by PCA, and we found out fitness of DBM shows positive correlation with total aliphatic GSLs, and negative correlation with total indole GSLs.

P83

A long-horn beetle's behavior sabotage and its ecological consequences

Juhee Lee[1†], Minsoo Choi[2†], Jeongmin Kim[1] and Yongsung Joo[1,3]
[1]Department of Biological Sciences and Biotechnology, Chungbuk National University
[2]Department of Biological Sciences, KAIST
[3]Department of Biology, Chungbuk National University

In the long evolutionary process of plants and insects, herbivorous insects have adapted in various ways to plant defenses. Nevertheless, herbivore adaptations against plant defenses have only focused on how herbivores detoxify plant toxic metabolites. Behavior adaptation is another strategy herbivores used to adapt to their host plants. *Phytoecia rufiventris,* a long-horn beetle, has a unique oviposition-associated behavior which called girdling; it cuts off vascular bundles on the stem to wither the upper part of the stem. Although the girdling behavior changes morphological and physiological changes of host plants, ecological consequences of the girdling has not been experimentally tested yet. Our results showed that upper part of girdled stem accumulated nutrients and decreased defensive compounds. Also, morphological changes of plants decrease appearance to other herbivores sharing the host plant. Our study suggest that herbivores are behaviorally able to neutralize plant defenses, which can also affect individual and community interactions.

Key words: *Phytoecia rufiventris*, counter-adaptation, girdling, plant resistance, plant-herbivore interaction

P84

Investigation of the occurrence and damage caused by *Limassolla koreana* in persimmon trees

Jae-Hyeok Choi[1], Ho-Wook Lee[1], Jong-Won Lee[1], Min- Jae Kim[2], Abraham Okki Mwamula[2], Yi Seul Kim[2], Jeong-Seok Ha[3] and Dong-Woon Lee[1,2*]
[1]Department of Ecological Science, Kyungpook National University, Sangju, Korea
[2]Department of Entomology, Kyungpook National University, Sangju, Korea
[3]Sangju Persimmon Research Institute, Gyeongsangbuk-do Agricultural Research & Extension Service, Sangju, Korea

Limassolla koreana has been associated with significant damage of persimmon, a major product in Korea. The damage inflicted through sucking persimmon leaves affects fruit production due to early deciduous leaves. In this study, density and rate of leaf damage were investigated by monitoring the leafhopper through yellow sticky traps over a period of time. Highest densities were recorded at the end of June, and damage was more evident in August, possibly due to the accumulative effect of the population.

Key words: leafhopper, persimmon, *Limassolla koreana*

P85

Surveillance of hard ticks in southern part of Gyeongsangbuk-do in Korea, 2022

Jun Hyuk Chang[1,2], Jiseung Jeon[1,2], Jihun Ryu[1,2], Min Hyeok Won[1,2], Jae Won Choi[1,2], Hyeon Seung Lee[1,2], Seung Pak An[1], Ye Jin Kim[1], Ye Won Jo[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 Phylogenomics and Evolution, Kyungpook National University, Daegu, Korea
[3]Research Research Institute for Dok-do and Ulleng-do Island, Kyungpook National University, Daegu, Korea

SFTS 바이러스의 매개체는 참진드기로, 바이러스를 보유한 참진드기가 숙주를 흡혈할 때 전파된다고 알려져 있다. 이러한 참진드기를 조사하기 위해 발생 감시를 4월부터 7월까지 매달 1회씩 실시하였다. 이를 위해, 김천시의 무덤, 산길, 잡목림, 초지 4곳에 각각 Dry ice trap을 3개씩 설치해 채집하였다. 채집된 참진드기는 1속 3종 1,912마리로 무덤에서 895마리(46.8%), 잡목림에서 425마리(22.2%), 초지에서 301마리(15.7%), 산길에서 291마리(15.2%) 채집되었다. 각 발생단계별로는 암컷 521마리(27.2%), 수컷 229마리(12.0%), 약충 836마리(43.7%), 유충 326마리(17.1%)가 채집되었다. 종별로는 *Haemaphysalis longicornis*가 1,897마리(99.2%)로 가장 많이 채집되었고 그 외에 *Amblyomma testidunarium* 12마리(0.6%), *Haemaphysalis flava* 3마리(0.2%)가 채집되었다. 채집된 참진드기의 SFTS 감염여부를 확인하기 위해 성충은 최대 5마리, 약충은 최대 30마리, 유충은 50마리씩 pooling하여 Nested PCR을 실시한 결과 모두 음성으로 확인되었다. 인간이 SFTS에 감염되었을 때 치사율이 높은 편이며, 백신과 치료제가 없기 때문에 참진드기에 대한 지속적인 감시가 필요할 것으로 생각된다.

검색어: 참진드기, *Haemaphysalis longicornis*, *Haemaphysalis flava, Amblyomma testidunarium,* SFTS

P86

Six insect pests on a seasoned vegetable, the Welsh onion, and their occurrence during spring onion culture

Md Tafim Hossain Hrithik, Bayisa Eticha Abdisa and Yonggyun Kim
Department of Plant Medicals, Andong National University

Welsh onion (*Allium fistulosum* L.) has been cultured in open field or greenhouse conditions in Korea. Spring onions are usually cultured in both conditions from April to August while autumn onions are cultured in greenhouses from October to March. This study reports insect pests on the onions during spring culture. Sex pheromone and yellow sticky traps were used to monitor the insect pests. Six insect species were observed during the cultivating seasons and included three flies (*Delia antiqua*, *Bradysia agrestis*, and *Liriomyza chinensis*), two moths (*Spodoptera exigua* and *Acrolepiopsis sapporensis*), and one thrips (*Thrips tabaci*). Most insects except *T. tabaci* were captured at early season before transplanting the onions, suggesting the overwintering populations. Three flies were captured without significant fluctuation in their capture numbers. *S. exigua* showed three occurrence peaks at April, June, and July/August until harvest at August. The last peak was prolonged until harvest. *A. sapporensis* showed a high overwintering population at March and April. Then, it was followed by at least three peaks during the onion cultivation. *T. tabaci* adults were captured just after the transplanting and increased the population size during the onion culture.

Key words: Welsh onion, insect pest, sex pheromone, yellow sticky, monitoring

P87

Surveillance of Mosquitoes (Diptera: Culicidae) in southern part of Gyeongsangbuk-do in Korea, 2022

Jiseung Jeon[1,2], Jihun Ryu[1,2], Min Hyeok Won[1,2], Jae Won Choi[1,2], Jun Hyuk Chang[1,2], Hyeon Seung Lee[1,2], Ye Won Jo[1], Seung Pak An[1], Ye Jin Kim[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

모기에 의해 전파되는 질병은 Flavivirus에 의한 것으로, 암컷 모기가 숙주의 혈액을 흡혈하는 과정에서 질병이 전파된다고 알려져 있다. 모기가 매개하는 대표적인 질병은 *Anopheles*속이 매개하는 말라리아, *Culex*속 모기가 매개하는 일본뇌염, 그리고 *Aedes*속이 매개하는 뎅기열, 지카바이러스감염증이 있다. 이러한 모기 조사를 위하여 2022년 3월부터 7월까지 도심(대구 북구 및 서구), 철새도래지(군위), 축사(대구 현풍) 3곳의 환경에서 채집을 진행하였다. 채집된 모기는 총 6속 9종 6,596마리로 이 중 도심지역에서는 총 556마리 중 *Culex pipiens* complex가 400마리(71.9%)로 가장 많이 채집되었고, 다음으로 *Aedes albopictus*가 90마리(16.2%) 채집되었다. 철새도래지에서는 총 18마리 중 *Culex pipiens* complex가 13마리(72.2%)로 가장 많이 채집되었다. 축사에서는 총 6,022마리의 모기가 채집되었으며 *Anopheles* spp.가 4,117마리(68.4%)로 가장 많이 채집되었고, *Culex pipiens* complex 959마리(15.9%), *Aedes vexans* 552마리(9.1%), 일본뇌염 주요 매개모기인 *Culex tritaeniorhynchus*는 402마리(6.6%)가 채집되었다. 채집된 모기의 Flavivirus 감염 여부를 확인하기 위하여 최대 30마리씩 pooling하여 Real-time PCR을 이용해 조사한 결과 모두 음성으로 확인되었다. 모기에 의한 질병은 매해 지속적으로 발생하므로 체계적인 감시와 조사가 필요할 것으로 생각된다.

검색어: Mosquitoes, Flavivirus, Aedes albopictus, Anopheles spp., Culex pipiens complex

P88

Effect of salinity stress on oviposition and growth of *Ochlerotatus togoi*

Jae Won Choi[1,2] and Kwang Shik Choi[1,2,3]

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

토고숲모기(*Ochlerotatus togoi*)는 인간에게 flavivirus와 사상충을 매개하는 위생 곤충으로 주로 해안가에 서식한다. 전 세계적으로 해수면이 상승하여 연안 담수 환경의 염도가 증가하고 있으며, 이로 인해 내염성 모기의 서식지가 늘어나 개체수가 증가할 것으로 우려된다. 이에 본 연구는 염도에 따른 토고숲모기의 산란 습성과 발달 조건에 대한 실험을 진행하여 부족한 생태적 정보를 제공하고자 한다. 샘플 채집은 포항, 거제도, 제주도에서 수행했으며, 0-35psu 범위의 염도를 5psu씩 8개의 구간으로 나누어 실험을 진행하였다. 실험 결과 0psu의 산란율이 27.66%로 산란선호도가 가장 높았으며, 염도가 높을수록 산란을 기피하는 경향을 보였다. 부화율은 10psu(69.08%)에서 가장 높았고, 이후 염도가 높아질수록 감소하였다. 용화율의 경우 염도가 높아질수록 증가하여 25psu(29.73%)에서 가장 높았으며, 이후 감소하였다. 우화율은 염도가 증가함에 따라 감소하였으며 35psu에서 78.53%로 가장 낮은 수치를 보였다. 이러한 결과는 향후 토고숲모기의 방제에 대응하기 위한 기초자료로 활용될 것으로 기대된다.

검색어: 토고숲모기, 산란선호도, 부화율, 용화율, 우화율

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Hatching rate of *Aedes albopictus* by temperature stress

Min Hyeok Won[1,2] and Kwang Shik Choi[1,2,3]

[1]School of Life Science, 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

뎅기열, 지카바이러스감염증 등 다양한 플라비바이러스를 매개하는 *Aedes albopictus*는 산란 시 기온, 습도, 광주기 등의 환경요소에 따라 휴면알과 비휴면알을 산란하는 습성이 있다. 본 연구를 통해 이들의 저온스트레스에 대한 부화율을 측정하여 저온 내성에 대한 연구를 수행하였다. 휴면알의 경우 21℃, 8:16(L:D)의 광주기, 40%의 습도에서, 비휴면알은 26℃, 16:8(L:D) 광주기, 70%의 습도에서 취득 후 실험에 이용하였다. 1회 실험당 100개씩 선별하여 저온 스트레스를 6단계의 온도(0℃/-2℃/-4℃/-6℃/-8℃/-10℃)와 8단계의 노출 시간(1h/2h/4h/8h/16h/24h/48h/72h)을 부여하여 부화율을 측정하였다. 이후 다중선형회귀분석을 통해 해당 변수들과 부화율 간에 회귀식을 도출하여 상관관계를 알아보았다. 비휴면알과 휴면알에 저온 스트레스를 부여하지 않았을 때 부화율은 각각 약 51.1%, 50.6%로 나타났다. 휴면알은 –6℃ 그리고 24h 이상 노출될 경우, 비휴면알에 비해 부화율이 평균 약 16.8% 상승하였다. 다중선형회귀분석을 통해 부화율은 저온 온도, 노출 시간, 휴면 유무 3개의 변수 중 휴면 유무에 가장 큰 영향을 받는 것을 확인하였다. 본 연구를 통해 비휴면알에 비해 휴면알의 저온스트레스 내성이 강한 것을 확인하였고, 추후 *Aedes albopictus* 생태 연구의 기초자료로 활용될 것으로 기대한다.

검색어: *Aedes albopictus*, hatching rate, temperature stress, 휴면알

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Evaluation of flora and insect fauna according to cultivation type of pear orchard in Chugcheongnam-do

Yoon-Sung Won, Yong-Seok Choi, Gun-Woo Lee, In-Soo Hwang and Gyeong Ju Lee
Chungnam Agricultural Research & Extension Services, Yesan 32418, Korea

본 연구는 배 생육초기 과원의 유기재배 및 관행재배 두곳에서 식물상 및 곤충상 조사를 수행하였다. 각각 과원의 내부 및 외부에서 조사를 실시하였으며 식물상은 Braun-blanket 방법으로 3반복 수행하였고, 곤충상은 트랩조사 및 스위핑 조사를 통해 식물상과 동일한 3반복으로 수행하였다. 배과원의 식물상 전체 조사결과 26개과 36종의 식물상이 관찰 되었으며, 유기포장은 17개과 26종이, 관행포장은 19개과 27종이 조사 되었다. 두포장의 식물상 우점도는 여뀌가 가장 높게 나타났으며, 각각 포장에서는 관행은 토끼풀이, 유기에서 여뀌가 가장 높게 나타났다. 곤충상은 전체포장에서 4가지목이 뚜렷하게 관찰 되었으며 각각포장에서 파리목이 가장 밀도가 높게 나타났다. 노린재목은 유기, 관행모두 중간정도로 비슷했으나, 진딧물의 밀도는 관행에서 좀더 높게 나타났다. 딱정벌레목은 관행보다 유기포장에서 밀도는 낮았으나 대부분 포식성이여서 천적활용에 도움이 될것으로 보여진다. 총채벌레목은 관행, 유기 모두 중간정도의 밀도를 보였다. 이러한 조사결과는 차후 배 재배농가의 생육초기 병해충 방제 연구의 기초 자료료 제공될 수 있을 것으로 기대된다.

Key words: 배 과수원, 식물상, 곤충상

P91

Occurrence status of *Metcalfa pruinosa* (Say) (Hemiptera: Flatidae)in Chugcheongnam-do

Yoon-Sung Won, Yong-Seok Choi, Gun-Woo Lee, In-Soo Hwang and Gyeong-Ju Lee
Chungnam Agricultural Research & Extension Services, Yesan 32418, Korea

미국선녀벌레(*Metcalfa pruinosa*)는 외래해충으로 2009년 발생 이후 지속적인 발생증가가 이루어져 왔고 산림뿐만 아니라 농경지에서도 큰 피해를 야기하고 있다. 충남도내에서 미국선녀벌레는 최초 발생이 확인된 충북지역과 경기지역에서 밀도가 증가하기 시작하여 현재는 충남 전역에 확산되어 있는 그 확산 정도를 파악하고 2017년, 2020년, 2022년 3개년 데이터를 비교하였다. 2017년도에는 아산과 예산을 중심으로 밀도가 높았으며 평균 밀도는 50cm 가지내 평균 1.9마리 수전이었다. 2020년에는 예산, 아산 보다 금산지역에서 밀도가 급격히 증가하였으며 평균 밀도는 8.0마리 였다. 2022년에는 금산과 인접한 논산, 당진에서 밀도가 급격히 증가하였다. 충남도내 전역에서 확인되었으며 평균밀도는 13.4마리 였다. 미국선녀벌레의 충남도내 평균 밀도는 2017년보다 2020년 4배, 2020년보다 2022년 2배의 밀도증가를 보이고 있어 충남도내에서 미국선녀볼레는 지속적인 밀도증가가 있을 것으로 생각된다.

Key words: 미국선녀벌레, 충청남도, 발생현황

P92

Development of candidate molecular marker for emamectin benzoate resistance in *Spodoptera exigua* (Lepidoptera: Noctuidae)

Su Ryeo Park[1], Hyun kyu Shin[1], Do Eun Lee[1] Ju Hyeon Kim[2] and Si Hyeock Lee[3]
[1]Department of Agricultural Biotechnology, Seoul National University
[2]Department of Tropical Medicine and Parasitology, College of Medicine Seoul National University
[3]Research institute of Agriculture and Life Science, Seoul National University

The Beet armyworm, *Spodoptera exigua* is a polyphagous pest causing world-wide economic loss. To control this pest, various synthetic insecticides including diamides are heavily used: however, indiscriminate use of insecticides has resulted in the development of resistance. For proper management of *S. exigua* insecticide resistance it is imperative to monitor resistance level at the early stage of development, which requires the development of robust molecular markers for rapid and accurate detection of resistance. In this study, we focused on the molecular mechanisms of *S. exigua* tolerance to emamectin benzoate (EB), a promising insecticide to control diamide-resistant. To this end, the molecular properties of putative two glutamate-gated chloride channel genes from *S. exigua* (*SeGluCl-a* and *SeGluCl-b*), the genes encoding the molecular target of EB, were characterized. Unlike *SeGluCl-b* only expressed in the head, *SeGluCl-a* was expressed in the cuticle as well as in the head, suggesting its extra role other than synaptic transmission. Injection RNA interference of *SeGluCl-a* in conjunction with bioassay suggested that *SeGluCl-a* likely function as a tolerance factor against EB contact toxicity. Current findings provide new insights into the defensive function of *SeGluCl-a* against EB and further suggest that the expression level of *SeGluCl-a* can be utilized as putative molecular marker for detecting EB resistance in *S. exigua*.

Key words: emamectin benzoate, glutamate-gated chloride channel, insecticide resistance, molecular marker

P93

Comparison of Control Effect of Drone and Pesticide Sprayer on *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae)

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

대파(*Allium fistulosum* L.)는 동양에서 옛날부터 중요한 식재료로 재배되어온 중국 원산지의 향신 채소이다. 적어도 통일신라시대부터 재배되어 온 기록이 있으며 현재에도 식재료로 수요가 많아 전국적으로 재배면적이 넓어지고 있고, 종자의 유통량 또한 많다. 대파에는 파굴파리(*Liriomyza chinensis*), 파좀나방(*Acrolepiopsis sapporensis*), 파밤나방(*Spodoptera exigua*) 등이 주요 해충으로 알려져 있다. 그 중에서도 가장 우점하는 파밤나방을 대상으로 하여 3종의 방제약제를 선발하여 기존 전통적인 방제 방법인 농약분무기를 이용한 방제와 드론(무인항공기)를 이용한 방제의 효과를 비교하고자 하였다. 실험은 국내의 대파 주 생산단지인 전남 진도에서 진행하였으며, 약효 평가는 7일간격 3회 약제를 처리 후 마지막 약제처리를 기준으로 7일 후에 피해엽수를 조사하였다. 본 연구에서 드론(무인항공기)의 방제력이 농약분무기의 방제력과 비등한 효과를 낼 수 있는지 확인하고자 실험을 실시하였고, 그 결과, 드론(무인항공기)은 방제 노동력 및 시간 절감에 효과가 있을 것으로 확인되었다.

검색어: 대파, 파밤나방, 방제, 드론, 농약분무기

P94

Application of soybean-based semiochemicals as a push-pull strategy to control the bean bug, *Riptortus pedestris*

Junyong Song[1], Gisuk Lee[1], Jinkyo Jung[2], Jung-Kyung Moon[2], Taein Kim[1], Yuhyeon Park[3], Tae-Hwan Jun[3], Soo-Kwon Park[2] and Sang-Gyu Kim[1]

[1]Korea Advanced Institute of Science and Technology, Department of Biological Sciences
[2]National Institute of Crop Science
[3]Pusan National University, Department of Plant Bioscience

The bean bug, *Riptortus pedestris*, is a major pest of soybean (*Glycine max*) and other fruit crops. Push-pull method, as a part of integrated pest management strategies is often applied to agricultural fields as an alternative to traditional chemical-based pest control methods. In a previous research, we have found a specific blend of soybean volatile organic compounds that induce orientation behavior of the bean bug in the lab conditions. This blend has a strong synergy in attracting the bean bugs in the field when mixed with commercial aggregation pheromone. We also found a specific blend of soybean semiochemicals to which the bean bugs show a strong repulsive behavior in the laboratory conditions. Here, we introduce an automated vertical olfactometer, a bioassay method where the beahvioral responses of an insect to different mixtures of host-plant volatiles can be tested much faster and easier compared to conventional behavioral bioassays. This experimental setup controls the flow and ratio of testing compounds computationally. We also suggest a Deep-Learning based three-dimensional object tracking, which can capture the three-dimensional movement pattern of a target insect. Significantly less number of the bean bugs were attracted to a soybean plant where this repulsive blend was treated compared to when only the attractant is treated. The application of the findings may further contribute to a development of a solid environmentally friendly integrated pest management against the bean bug.

P95

Construction of entomopathogenic fungal library to control melon thrips, *Thrips palmi*

Putri Novadhea Salsabilla[1], So Eun Park[2], Ye Ram Im[2] In Soo Jeon[2], Yu Lim Park[2], Yu Jin Jeong[2], Ki Jung Kim[2], Ga Hyeon Song[2], Hanna Yang[2], Jong Cheol Kim[2] and Jae Su Kim[1, 2]

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

[2]Department of Agricultural Biology, College of Agriculture & Life Sciences, Jeonbuk National University

Melon thrips, *thrips palmi* is a pest that damage crops and a vector of plant viruses. Chemicals are mostly used to control *T. palmi* but they developed resistance. Therefore, alternatives control are needed. Entomopathogenic fungi could be used to control *T. palmi*, but further research is still being developed. In this study, we constructed entomopathogenic fungal library and investigated the virulence against *T. palmi*. We isolated 27 isolates from soil in Red Oreum Mountain and 18 isolates in Jeju Gyorae. For the virulence test against *T. palmi* using a leaf-dipping method, we investigated 27 isolates from Red Oreum Mountain and 18 isolates from Jeju Gyorae. As a result, eight isolates from Red Oreum Mountain and ten isolates from Jeju Gyorae, showed 100% mortality in six days after treatment. This study represents that our fungal library isolates could be potential for biological control of *T. palmi.*

Key words: Entomopathogenic fungi, Thrips palmi, fungal library, virulence tests

P96

Detection of pesticide resistance mutations in *Haemaphysalis longicornis* and *Anopheles sinensis* with droplet digital PCR

KyungHwan Moon[1], YeongHo Kim[2] and Young Ho Kim[1,2]

[1]Department of Vector Entomology, Kyungpook National University

[2]Department of Ecological Science, Kyungpook National University

Droplet digital PCR (ddPCR) enables precise and sensitive quantification of gene expression levels, and a highly sensitive diagnostic method using ddPCR for accurate detection of low-frequency mutations associated with pesticide resistance has been recently developed in our previous study. In this study, we investigated pesticide resistance mutations in acetylcholinesterase 1 (AChE1) and voltage-sensitive sodium channel (VSSC) of *Hamaphysalis longicornis* and *Anopheles sinensis* collected from 17 and 25 sites in Korea, respectively, using ddPCR. No mutations were detected in *H. longicornis*, whereas resistance mutations were detected in *A. sinensis* population in the range of 20-90%, depending on the collection sites.

Key words: droplet digital PCR, mutation, detection, acetylcholinesterase 1, voltage-sensitive sodium channel

P97

Insecticide resistance monitoring in *Bemisia tabaci* in the Republic of Korea

Gyeongmo Gu[1], Garyoung Lee[2], Jiseok Kim[1]and Donghun Kim[1,2]

[1]Department of Vector Entomology, Kyungpook National University, Sangju, Republic of Korea
[2]Department of Applied Biology, Kyungpook National University, Sangju, Republic of Korea

담배가루이(*Bemisia tabaci*)는 오이와 토마토, 고추 등 주요 시설재배 작물을 흡즙하여 식물 생장을 억제하고 감로를 배설함으로써 그을음병을 유발하는 주요 농업 해충이다. 또한 Tomato yellow leaf curl virus (TYLCV)를 포함한 100여종의 바이러스를 매개하여 심각한 경제적 피해를 유발한다. 고추는 배추, 무, 마늘, 양파와 함께 국내 소비 5대 작물 중 하나로 온실과 노지에서 재배되고 있다. 고추 시설재배지에서 담배가루이는 연간 10세대 이상 발생하며 화학적 방제법으로 관리되고 있다. 지속적인 살충제 살포는 담배가루이의 약제 저항성 발달로 이어져 효율적인 방제를 방해하는 주요 요인이 된다. 따라서 전국 고추 시설재배지에서 발생하는 담배가루이의 약제저항성 평가를 통해 약제 선정 및 대체 약제 제시 등 지속가능한 해충관리법을 제시하고자 한다. 본 연구에서는 작용기작별 사용량이 많은 8종의 살충제를 선발하여 영남권(사천), 호남권(나주), 그리고 충청권(당진)에서 채집된 담배가루이의 약제저항성을 평가하였다. 담배가루이 3령 약충을 대상으로 엽침지법을 통해 약제 권장 사용 농도의 1/4배 및 1/2배, 1배, 2배, 4배의 살충률을 조사하였다. 가장 높은 살충률을 보이는 약제는 아버멕틴으로 약제 권장 사용 농도의 4배에서 나주, 당진, 사천이 각각 100%, 100%, 94.1%의 살충률을 보였다. 피리프록시펜은 나주와 사천이 각각 72.7%, 65%로 7.7%의 차이를 보였고 당진이 28.6%로 가장 낮은 살충률을 보였다. 비슷하게 스피노신 또한 나주와 사천에서 각각 70%, 69.2%로 0.8%의 근소한 차이를 보였고 당진이 33.3%로 가장 낮은 살충률을 보였다. 설폭시민은 나주의 살충률이 55.5%로 가장 높았으며 다음으로 당진과 사천이 각각 30%, 21.1%이다. 네오니코티노이드는 나주, 당진, 사천이 각각 40%, 33.3%, 34.5%의 살충률을 보였다. 나주와 당진, 사천 담배가루이 개체군은 아버멕틴 약제 처리에서 가장 낮은 생존율을 보였다. 지역별 가장 낮은 살충률을 보인 약제는 나주와 당진, 사천에서 각각 네오니코티노이드, 피리프록시펜, 설폭시민이다. 향후 연구에서는 경기권, 강원권 담배가루이 개체군 채집 및 생물검정을 통해 전국 고추 시설 재배지에서 발생하는 담배가루이의 약제 저항성 지도 제작 및 지역별 효과적인 살충제를 선정하고자 한다.

검색어: 담배가루이, 고추, 약제저항성, 살충제, 생물검정

P98

Colonization of *Beauveria bassiana* on cucumber phyllosphere for cotton aphid control

Yeram Im[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

Cotton aphid, *Aphis gossypii* is a pest that causes serious damage by sucking plant sap as well as transmitting plant viruses. Chemical insecticides have been used to control cotton aphids, but they lead to resistance in aphid population. Alternatively, entomopathogenic fungi could be used to control cotton aphid. Some of entomopathogenic fungi, including *Beauveria bassiana*, are known to be endophytically colonized on phyllosphere. In this study, it was investigated whether *B. bassiana* isolates with insecticidal activity against cotton aphids could colonize on the phyllosphere. Cotton aphid-pathogenic fungal isolates were treated on cucumber leaves and in two weeks cotton aphids were infested on the incubated leaves. The treated aphids were killed much faster than non-incubated treatment. In addition, phyllosphere colonization was observed using egfp tagging fungal isolates generated by *Agrobacterium tumefaciens* mediated transformation. This work suggests that the *B. bassiana* could colonize on the cucumber leaves and it could be used to control cotton aphids for a long-term management.

Key words: AtMT, *Beauveria bassiana*, Cotton aphid, Entomopathogenic fungi, Phyllosphere colonization

P99

Biological control of root-knot nematode using *Beauveria bassiana* JEF-503

Ki-Jung Kim[1], So Eun Park[1], Yeram Im[1], Hanna Yang[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

Root-knot nematode (RKN) cause damages many crops which is about 40% of total of greenhouse farming and forms huge galls by attacking the roots of crops. The problem of most chemical nematicides is that they have residual toxicity in soil and crops. In this study, nematicidal activity of entomopathogenic fungi (EPF) was investigated in *in vivo* and *in vitro* bioassay. A total of ten isolates were used for the nematicidal activity test, and *Beauveria bassiana* JEF-503 treatment significantly decreased the production of RKN eggs. In the *in vitro* test, *B. bassiana* JEF-503 showed nematicidal activity against juvenile and adult stages. In the pot test, thenumber of RKN eggs decreased in the JEF-503 treatment. In summary, JEF-503 could be used to manage root-knot nematode with an environmentally sound way.

Key words: Plant parasitic nematodes, Root-knot nematodes, entomopathogenic fungi, biological control

P100

Transcriptome analysis of *Spodoptera frugiperda* exposed to *Beauveria bassiana* JEF-492

Insoo Jeon[1], Yeram Im[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 that cause severe yield loss of crops. Long-term and overuse of insecticides makes fall armyworm develop resistance. The use of entomophathogenic fungi is an alternative method to control fall armyworm. Herein, the response of fall armyworm to infection by *Beauveria bassiana* JEF-492 at two different time courses (2 days, 4 days) was analyzed at a transcriptional level. At 2 days post-infection, differentially expressed genes (DEGs) from immune were mostly enriched to ECM-receptor interaction and Toll and Imd signaling pathways when compared to non-infected cotrol. The DEGs from 4 days post-infection were significantly enriched to Wnt signaling pathway. This study will provide the knowledge how fall armyworm is respoding to the fungal infection.

Key words: biological control, entomopathogenic fungi, RNA-seq, *Spodoptera frugiperda*

P101

Effect of LdMNPV and *Bacillus thuringiensis* var. *kurstaki* on *Lymantria dispar asiatica* in Korea

Hwal-Su Hwang[1], Lucas Mezione de Carvalho[1], Susant Raj Sharma[1], Rajendra Acharya[1,2] and Kyeong-Yeoll Lee[1]
[1]Department of Applied Biosciences, Kyungpook National University
[2]Department of Entomology, Kyungpook National University

아시아매미나방(*Lymantria dispar asiatica*)은 2019~2020년에 경기, 충북, 경북, 강원 등 지역에서 돌발적으로 대발생한 바 있다. 매미나방의 알 및 유충을 채집하여 살펴본 결과 곤충병원성곰팡이, 핵다각체병바이러스, 기생파리, 알좀벌과 같은 다양한 천적이 발견되었다. 곤충병원성 방제인자로서 핵다각체병바이러스 (LdMNPV)와 *Bacillus thuringiensis kurstaki* (Btk)를 농도별로 유충에 처리하여 살충률과 살충기간을 조사해 본 결과 LdMNPV는 3×10^6 POB/ml에서 평균 10일 이내에 100%의 살충률을 나타냈다. Btk는 1.6×10^3-10^5 IU/ml 수준에서 2-4일이내에 100% 살충되었다. 두 제제를 혼합하여 처리한 결과 Btk 단일 처리와 유사하게 나타났다. 본 연구 결과를 바탕으로 아시아매미나방의 생물적 방제를 위한 기초자료로 활용할 수 있다.

검색어: 기후변화, 돌발 해충, 생물적 방제, 천적, 곤충병원성 미생물

P102

Screening of feeding deterrent activity of plant essential oils in the tobacco cutworm, *Spodoptera litura*

Hyo Eun Jeon[1] and Jun-Hyung Tak[1,2]
[1]Department of Agricultural Biotechnology, Seoul National University
[2]Research Institute of Agriculture and Life Science, Seoul National University

에센셜 오일은 합성 살충제의 대안이 될 수 있는 휘발성 화합물로 살충제, 기피제, 섭식저해제 등으로 사용된다. 그러나 에센셜 오일은 해충에게 지속적인 미각 자극을 주었을 때, 습관화(habituation)가 발현되어 섭식저해 및 기피력이 감소하는 단점이 있다. 따라서 본 연구에서는 미각 수준에서 에센셜 오일의 습관화 현상과 작용기작을 확인하기 위해 담배거세미나방(*Spodoptera litura*)의 3령 유충에 대해 평가했다. 30가지 오일의 섭식저해도와 살충력을 확인하기 위해 non-choice 실험과 접촉 및 훈증 실험을 진행한 결과, lemongrass, fennel sweet, geranium 순으로 효과가 좋았으며, 살충력과 섭식저해 간의 상관관계가 있었다. 또한, 습관화 현상을 확인하기 위해 3가지 오일을 사료에 1 mg/g 농도로 섞어 48시간 동안 유충에게 급여한 후, choice 실험을 진행한 결과 3가지 오일 모두 대조군과 비교하였을 때 섭식저해도와 기피력에서 유의미한 감소를 보였다.

검색어: 담배거세미나방, 섭식저해, 미각자극, 습관화

P103

Acute toxicity of Ethyl formate fumigation towards silkworm (*bombyx mori*) larvae

Donghyeon Kim[1], Kyeongnam Kim[2], Chaeeun Kim[2], Yerin Cho[2], Yurim Kim[2], Yubin Lee[1] and Sung-Eun Lee[1,2]
[1]Department of integrative Biology, Kyungpook National University, Korea
[2]Department of Applied Biosciences, Kyungpook National University, Korea

Due to climate change and the increase in international trade, sucking insect pests are being introduced to our agricultural environments. Application for controlling sucking insect pests using ethyl formate (EF) in the greenhouse has recently been studied, but studies on the toxicity of EF to useful insects are insufficient. In this study, the acute toxicity of EF to silkworms was performed at two time points (2h and 4h) on a lab scale. As a result of 2h-EF fumigation for controlling agricultural insect pests, the lethal concentration-time $(LCT)_{90}$ value was reached to 41.14 mg·h/L. With the result of 4h-EF fumigation in relation to quarantine level, LCT_{99} value was 68.85 mg·h/L. Each LCT value confirms that the silkworm is more resistant to EF than the major sucking insect pests, implying that EF may be safe to use it in the field.

Key words: green house, ethyl formate, pest control, silkworm, acute toxicity

P104

Ethyl formate, a new fumigant against Chestnut weevil, *Curculio sikkimensis*

Junheon Kim[1], Tae Hyung Kwon [2] and Byungho Lee[2]
[1]Forest Entomology and Pathology Division, National Institute of Forest Science
[2]Institute of Quality & Safety Evaluation of Agricultural Products, Kyungpook National University

Castanea crenata Siebold & Zucc. (Fagales: Fagaceae), a species of chestnut native to Korea and Japan, is distributed in Korea, Japan, and northeastern China, where chestnuts are a major economic agroforest product. *Curculio* spp. is among the main known pests of chestnuts around the world. In Korea, only phosphine (PH3) is permitted for the fumigation of *C. sikkimensis* larva-infested chestnuts. However, it is applied for large-scale fumigation, and its use is restricted. Moreover, it requires a long exposure time and an application device; thus, it cannot be used by small-scale farmers. In this study, the activity of ethyl formate (EF) as a fumigant against *C. sikkimensis* in chestnuts was investigated, and its potential for practical use by farmers was evaluated. The sorption of EF according to the filling ratio (FR) and fumigation time was tested, and the results revealed that 2.5% FR was the most effective. According to the time–dose mortality data collected over 12 h of fumigation, the LCT_{90} and LCT_{99} values were estimated as 1052.0 and 1952.0 g·h/m^3. Based on the LCT values, a dose of 180.0 g/m^3 and 12 h of fumigation resulted in 100% mortality on a small scale (2 m^3). The results of this experiment indicate that EF could be conveniently used as a fumigant by farmers.

Key words: Chestnut; *Castanea crenata*; fumigation; safety

P105

Changes in microbiome of *Tetranychus urticae* according to entomopathogenic fungal infection

Gahyeon Song[1], So eun Park[1], Yeram Im[1], Yujin Jeong[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, Korea

Two-spotted spider mite (*Tetranychus urticae*, TSSM) is a polyphagous pest that occurs in fruit and vegetable crops. TSSM has acquired acaricide resistance because of its short life cycle and continuous exposure to acaricides. Therefore, we tried to solve this problem with the entomopathogenic fungal group. TSSM has symbiotic microorganisms and they are involved in TSSM survival against unfavorable abiotic stresses. In this study, entomopathogenic fungi showing high acaricidal activity were selected and microbiome change of the TSSM infected with entomopathogenic fungi is being under analysis. The acaricidal activity of 77 fungal isolates was tested under laboratory conditions. On the 7th day of treatment, 15 isolates showed 100% acaricidal activity. For microbiome analysis, TSSM 16S rRNA and ITS gene sequencing was performed. It is planned to be compared to the infected TSSM. This study will provide an understanding of TSSM symbiotic system against entomopthogenic fungi infection.

Key words: Acaricidal activity, biological control, entomopathogenic fungi, microbiome, *Tetranychus urticae*

P106

Evaluation of the efficacy of Emamectin benzoate and Acetamiprid Mixed pesticides on Japanese Pine Sawyer, *Monochamus alternatus,* by branch spray

Ho-Wook Lee[1], Jae-Hyeok Choi[1], Jong-Won Lee[1], Abraham Okki Mwamula[2], Ki-Bo Sim[3], Kwon Su Kim[4] and Dong-Woon Lee[1,2*]

[1]Department of Ecological Science, Kyungpook National University, Sangju, Korea
[2]Department of Entomology, Kyungpook National University, Sangju, Korea
[3]Division of Forest Research, Gyeongsangnam-do Forest Environmental Research Institute, Jinju, Korea
[4]Hallasan Research Department, World Heritage Office, Jeju Special Self-Governing Province, Jeju, Korea

Mixed pesticides which control pine wood nematode (PWN) and Japanese pine sawyer, the vector insect, are an efficient control method to prevent PWD. However, evaluation of pesticidal effect of each formula and their respective active ingredient has not been widely done. This study was conducted to evaluate the potency of emamectin benzoate and acetamiprid single compounds, and their mixtures on Japanese pine sawyer. Result shows that acetamiprid as the single compound was the most effective formulation, with an LC_{50} of 2.065ppm at 1 day after treatment. Moderate efficacy was evident in mixed compounds, and emamectin benzoate single compound was the least effective formulation.

Key words: *Monochanus alternatus*, mortality, nematicidal, emamectin benzoate, acetamiprid

P107

Oral administration of *Beauveria pseudobassiana* inactivate blood-feeding behavior and reproduction capability against *Anopheles stephensi*

Shoma Kawa[1], Masanori Koike[1], Hirotaka Kanuka[2] and Daigo Aiuchi[1]

[1]Obihiro University of Agriculture and Veterinary Medicine, Japan
[2]The Jikei University School of Medicine, Japan

Entomopathogenic fungi infect insects through oral ingestion of and cuticle contact with conidia. Our previous study showed the direct lethal effect of oral administration of *Beauveria pseudobassiana* on *Anopheles stephensi*. In this study, the sub-lethal effects of orally administered fungus were evaluated on blood feeding and egg production. Decreased rates of blood feeding behavior and follicle development were observed 2 days after oral conidial suspension administration. However, the amount of blood feeding was not changed. These results show sub-lethal effects of oral administration of fungus against mosquitoes, including inactivation of blood feeding behavior and reproduction capability.

Key words: *Anopheles stephensi*, *Beauveria pseudobassiana*, oral administration, blood feeding, reproduction, behavioral change

P108

Changes in the responsiveness of honey bee umami receptors induced through bio-structure modeling and point mutation

Seungha Lee, Hyung Yeon Park 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

Honey bees need essential nutrients such as proteins, minerals, lipids, and vitamins to survive. Some of these amino acids are only present in pollen, among the food resourses that honey bee usually gathers. In order to obtain pollen with these essential nutrients, it is important to sense it through chemosensory organs such as taste and smell. Among them, gustatory receptor 10 (Gr10) in honeybees is known to detect umami. However, it is nearly unknown about the interaction between the three-dimensional structure of Gr10 and its ligand in honeybees. The molecular interactions of Gr10 with umami amino acids were studied *in silico* and *in vivo* in this study. First, we explored the binding site of ligand and Gr10, and investigated the binding pose and binding energy. Based on this *in silico* modeling, *in vivo* experiments were carried out, and Gr10 was expressed in HEK-293T cells, and calcium imaging experiments were performed on monosodium glutamate (MSG), a representative umami amino acid. From this, it was found that the response of the Gr10 mutant to MSG was lower than that of the wild-type Gr10 or no response at all. As a result, our research is expected to add to the basic knowledge of the molecular biology of honey bee chemosensory receptors through mutations in the Grs gene in honey bees.

Key words: *Apis mellifera*, chemosensory, gustatory receptor, binding energy, cell calcium imaging

P109

Population genetics study for tracing the origin of *Solenopsis geminata* in South Korea, using 66 microsatellite markers

Sohee Kim[1,2], Hyojoong Kim[2], Heung-Sik Lee[1], Hyun-jik Lee[1], Seonwoo Lee[1], Soo-Jung Suh[1] and Jong-Ho Lee[1]
[1]Animal & Plant Quarantine Agency, Gimcheon 39660, Republic of Korea
[2]Animal Systematics Laboratory, Department of Biology, Kunsan National University 54150, Republic of Korea

The managed pest tropical fire ant (*Solenopsis geminata*) is known to be native to South America, and since the 16th century, global trade has been active and has spread to each region through container cargo. Currently, it is reported that damage such as ecosystem disturbance occurs in the area where this species has invaded, and many studies are being conducted. In Korea, it was found in Busan and Gwangyang ports and inland containers. In this study, in order to analyze the genetic structure of these populations and trace their origin, we used 66 *Solenopsis* microsatellite markers for 25 populations, including Korea, Taiwan, and the United States, and 157 individuals. The genetic structure of each group was compared. As a result of the analysis, it was confirmed that the tropical fire ants found in Korea were very similar to the populations of Southeast Asian countries such as Thailand, Laos, and Vietnam, and showed a genetic difference from the populations of the United States.

Key words: *Solenopsis geminata,* microsatellite, population genetics, epidemiology, quarantine, trace origin

P110

Population genetics study of Red imported fire ant, *Solenopsis invicta*, for tracing the origin of the population of invaded South Korea, using microsatellite markers

Sohee Kim[1,2], Hyojoong Kim[2], Heung-Sik Lee[1], Hyun-jik Lee[1], Seonwoo Lee[1], Soo-Jung Suh[1] and Jong-Ho Lee[1]

[1]Animal & Plant Quarantine Agency, Gimcheon 39660, Republic of Korea

[2]Animal Systematics Laboratory, Department of Biology, Kunsan National University 54150, Republic of Korea

The red fire ant (*Solenopsis invicta* (RIFA: Red imported fire ant)) is native to Central America. It is an invasive pest that spreads to countries around the world by hitchhiking traded products, disturbs the ecosystem, and causes damage by attacking people and livestock. In Korea, since the first discovery at Gamman port in Busan in 2017, as of 2022, it was found 19 times in yards and import cargo containers at trade ports such as Incheon, Pyeongtaek, and Gwangyang. In this study, population genetic analysis was performed using 66 microsatellite markers on samples of 47 groups collected domestically and abroad to identify the origin of red fire ants that invaded Korea. As a result of the analysis, the red fire ant colony that invaded Korea was genetically similar to East Asian populations such as Taiwan and China, and was different from the American population. These results indicate that the red imported fire ant groups found in Korea are likely to invade from East Asia, such as China and Taiwan.

Key words: *Solenopsis invicta,* microsatellite, population genetics, molecular epidemiology, trace origin

P111

Haplotype Network Analyses of Two Fire ants Species in genus *Solenopsis* Based on Sequences of COI-COII

Sohee Kim[1,2], Hyojoong Kim[2], Heung-Sik Lee[1], Hyun-jik Lee[1], Seonwoo Lee[1], Soo-Jung Suh[1] and Jong-Ho Lee[1]

[1]Animal & Plant Quarantine Agency, Gimcheon 39660, Republic of Korea

[2]Animal Systematics Laboratory, Department of Biology, Kunsan National University 54150, Republic of Korea

Global climate change and human trade expansion have caused intercontinental migration of various species. These moved pests are causing various problems in the invaded area. *Solenopsis invicta* and *S. geminata* are causing many problems, such as agricultural and ecological damage, in the infested areas. This study was conducted to trace the origin of two fire ants invading Korea and to identify the haplotype differences by group. In *S. invicta*, the 770bp region of the COI-II region was barcoded for 170 individuals from 4 countries. As a result, two types of haplotypes were identified in the intrusion group in Korea. For *S. geminata*, the 567bp nucleotide sequence of the COI region of 167 individuals from 8 countries. As a result of the analysis, they showed a clear haplotype difference between the Southeast Asian population and the American population, and the Korean individuals were similar to the Southeast Asian haplotype population.

Key words: *Solenopsis invicta, Solenopsis geminata,* haplotype network, barcoding, COI, COII, trace origin

P112

Identification of domesticated silkworm varieties using single nucleotide polymorphisms detected from mitochondrial genomes

Jong Woo Park[1†], Jeong Sun Park[2†], Chan Young Jeong[1], Sang Kuk Kang[1], Seong-Wan Kim[1], Nam-Suk Kim[1], Kee Young Kim[1] and Iksoo Kim[2*]

[1]Department of Agricultural Biology, Rural Development Administration, Republic of Korea
[2]Department of Applied Biology, Chonnam National University, Republic of Korea

Different varieties of silkworms have functional differences; thus, there is an emerging need for variety identification. In this study, we sequenced complete mitochondrial genomes (mitogenomes) of ten government-recommended silkworm varieties. Comparison of these sequences allowed us to select the single nucleotide polymorphisms (SNPs) in 34 sites that are specific to six silkworm varieties. Among these each one SNP per variety was amplified by preparing variety-specific primers and then using tetra-primer amplification refractory mutation system PCR (Tetra-ARMS-PCR). As a result, it was possible to identify these six varieties among the ten silkworm varieties, evidencing that SNPs developed from mitogenomes are useful marker for the discrimination of genetically closer silkworm varieties.

Key words: Silkworm, Mitochondrial genome, Single Nucleotide Polymorphism, Tetra-ARMS-PCR

P113

Development of a loop-mediated isothermal amplification assay for the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae), using species-specific inserted sequences

Jeong Sun Park[1], Keon Hee Lee[1], Min Jee Kim[2], Deuk-Soo Choi[3], Kyeong-Yeoll Lee[4], Tariku Tesfaye[5] and Iksoo Kim[1*]

[1]Department of Applied Biology, Chonnam National University, Republic of Korea
[2]Honam Regional Office, Animal and Plant Quarantine Agency, Republic of Korea
[3]Department of Plant Quarantine, Animal and Plant Quarantine Agency, Republic of Korea
[4]Department of Applied Biosciences, Kyungpook National University, Republic of Korea
[5]Ethiopian Institute of Agricultural Research, Ambo Agricultural Research Center, Ethiopia

The fall armyworm (*Spodoptera frugiperda*, FAW) is now annually arrives in Korea from China with the assistance of seasonal wind. We developed loop-mediated isothermal amplification (LAMP) assay which is a rapid identification of target species. To design LAMP primers whole genomes were sequenced by NGS method. LAMP assay provided consistent amplification reaction in five loci when ten FAWs, and collected from eight localities in four countries were tested, in contrast to 13 non-target lepidopteran species. To increase in-field applicability of the method life stages, outdoor exposure time, reaction time, DNA concentration, and stability of pre-mixed primer plus isothermal master mixture are in the middle of testing using the quick extracted DNA.

Key words: Fall armyworm, *Spodoptera frugiperda*, Loop-mediated isothermal amplification

P114

Exploration for genes related to climate change adaptation of *Cryptotympana atrata Fabricius*, 1775 (Hemiptera: Cicadidae)

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

곤충은 변온동물로 발생 및 생활주기가 기후와 밀접하게 연관되어 지구온난화의 영향에 매우 민감한 것으로 알려져 있다. 본 연구에서는 대표적인 남방계 매미로 기후변화민감종인 말매미의 기후 변화 적응과 관련하여 높은 연관성을 가지는 기후요인 추론 및 이와 연관된 유전자를 알아보고자 하였다. 평균온도 및 강수량 비교를 통해 통계적으로 유의한 4개 지역의 말매미를 확보하여 전장유전체 비교 분석을 통해 지역에 따른 유전적 차이를 보이는 SNP를 선발하였다. 기후 변화 적응과 연관된 유전자를 알아보고자 기후요인에 따라 4개 집단을 그룹화하고 선발된 SNP를 이용하여 F_{ST}분석을 통해 그룹 간 확실한 차이를 보이는 SNP를 재선발하였으며, 이들을 이용한 pathway 분석 결과 말매미의 기후 변화 적응은 온도와 큰 연관성이 있음을 추론하였다.

검색어: 말매미, 기후변화민감종, 전장유전체, SNP, 기후 변화 적응

P115

Mitochondrial *COI*-based population genetic analysis of the cicada, *Cryptotympana atrata* Fabricius, 1775 (Hemiptera: Cicadidae), which is a climate-sensitive indicator species in Korea

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

기후온난화에 따른 북위로의 서식처 확장과 이에 따른 집단의 유전적 다양성 변동 특징에 대한 이해는 장기적 측면의 한반도 생물다양성 이해를 위한 초석이라고 할 수 있다. 본 연구에서는 우리나라 100종의 기후변화민감종 중 유일한 노린재목 곤충이자 도심 고온 환경에 잘 적응한 곤충인 말매미 (*Cryptotympana atrata* Fabricius, 1775)의 mitochondrial *COI* 유전자의 염기서열을 이용하여 11개 집단의 유전적 다양성, haplotype 계통, 집단구조 등에 대한 분석을 수행하였다. 그 결과, 내륙에서 가장 높은 빈도로 광범위하게 발견되는 haplotype은 제주도에서는 전혀 발견되지 않고 제주도에서 가장 높은 빈도로 발견되는 haplotype은 내륙 내 부산과 광주에서 소수로 발견되어 제주도와 내륙은 다른 유전자풀을 구성하였다. 향후 이에 대한 지속적인 모니터링이 필요하고 아울러 유전체 기반의 연구를 통한 심도있는 결과 도출이 필요한 실정이다.

검색어: 말매미, 기후변화민감종, *COI*, 유전자풀

P116

Development of diagnosis method for the Korea endemic silkworm strains of *Bombyx mori* (Lepidoptera: Bombycidae) using whole 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, Republic of Korea
[2]Honam Regional Office, Animal and Plant Quarantine Agency, Republic of Korea
[3]Department of Agricultural Biology, Rural Development Administration, Republic of Korea

The endemic silkworm strains are important biological resources to breed new silkworm strains which have new traits. Silkworm strains are very difficult to distinguish due to the morphological similarity of larvae and adults. Thus, We developed molecular diagnosis method to distinguish five silkworm strains, which are endemic to Korea using whole genome sequences. The diagnosis method was developed using "Decision tree model" to distinguish each endemic strain from four endemic and 35 stock strains due to difficulty in applying one shot diagnosis method, caused by genetic similarity among silkworm strains. This method is reliable and efficient, so can be used to identify the five endemic silkworm strains, preserved in Korea.

Key words: Silkworm, Whole-genome, Single nucleotide polymorphism, Decision tree, Molecular diagnosis

P117

Comparison of surface display efficiency of target protein by GP64 and VSV-G in insect cells

Hyuk Jin Moon, Kyu Seek Kim, Do Young Kim, Hyun Jung Kim, Dong Hyun Lee, Hyun Soo Kim and Soo Dong Woo
Department of Agricultural Biology, Chungbuk National Unviersity, Republic of Korea

Surface display is a valuable protein engineering technology that maintains a relatively independent spatial structure and biological activity for proteins by anchoring target proteins on the surfaces of cell or virus. Surface display technology in baculovirus expression system (BES) is more efficient than other host-based systems because it allows post-translational modification and the expression of complex folding proteins. GP64 from baculovirus or versicular stomatitis virus glycoprotein (VSV-G) has been used for surface display expression in BES. However, comparative evaluation of the surface expression efficiency between them has not been conducted so far. In this study, the production and surface display efficiency of the target protein according to the use of GP64 or VSV-G for the surface expression were compared.

Key words: surface display, baculovirus, GP64, VSV-G

P118

Construction of the recombinant bacmids for the stabilized protein expression in insect cell

Jong Ho Lee, Hyun Soo Kim and Soo Dong Woo
Department of Agricultural Biology, Chungbuk National University, Korea

The baculovirus expression system (BES) is widely used for the production of useful proteins through the construction of recombinant viruses. Recombinant viruses are generated using a method of homologous recombination or Tn7 site-specific transposition between a target gene and viral DNA. In particular, a bacmid is conveniently used in BES because it can easily produce a recombinant virus by transposition of a target gene in Escherichia coli, but the low stability of the recombinant virus by this method is pointed out as a problem. In this study, the stability of the recombinant virus according to various transposition locations of the target gene in bacmid was evaluated, and the transposition site of the target gene was determined to produce a recombinant virus with increased stability.

검색어: Baculovirus expression system, Bacmid, Stability, Protein expression

P119

Nanoparticlization of Recombinant Protein by Polyhedrin-Fused Expression in Baculovirus Expression System

Seul Ki Kim[1], Cheol June Choi[2], Hyun Soo Kim[1], Dong Hyun Lee[1] and Soo Dong Woo[1]
[1]Department of Agricultural Biology, Chungbuk National University, Republic of Korea
[2]R&D Center, EuBiologics Co., Ltd., Republic of Korea

The baculovirus expression system (BES) is widely used for the production of recombinant antigen proteins for various vaccines. It has been reported that recombinant antigen proteins have high stability and immunogenicity when they exist in the size of nanoparticles (1-100 nm). In addition, when partial polyhedrin of *Autographa californica* multiple nucleopolyhedrovirus (AcMNPV) and target protein are fused, fused protein aggregation has occurred, raising the possibility that the recombinant proteins exist as nanoparticles. Therefore, this study evaluated the possibility of nanoparticlization of recombinant proteins by fusing enhanced green fluorescent protein (EGFP) and partial polyhedrin.

Key words: BES, polyhedrin, recombinant antigen, nano particle

P120

Effect of actin overexpression on the activity of *p10* and *polh* promoters in Sf9 cells

Hyo Gyeong Jang, Hyun Soo Kim, Seul Ki Kim, Do Young Kim, Jin Woong Im, Seoyeong Mun and Soo Dong Woo
Department of Agricultural Biology, Chungbuk National University, Republic of Korea

The baculovirus expression vector system (BEVS) primarily utilizes the *p10* or *polh* promoters of *Autographa californica* nucleopolyhedrovirus (AcNPV) or *Bombyx mori* NPV (BmNPV) to produce a lot of useful recombinant proteins. Various studies have been conducted to increase the yield of recombinant proteins produced by BEVS, and it has recently been reported that the target protein production by recombinant BmNPV is increased through overexpression of actin in BmN cells. In this study, we evaluated the effect of actin on the production of target proteins by recombinant AcNPV in Sf9 cells.

Key words: baculovirus, actin, *p10* promoter, *polh* promoter, Sf9

P121

A report on the complete mitochondrial genome sequence of *Vespula shidai* (Hymenoptera: Vespidae)

Seung-Su Euo[1], Jeong-Hwan Choi[1], Moon-Bo Choi[2], Il-Kwon Kim[1] and Chang-Jun Kim[3]
[1]Division of Forest Biodiversity, Korea National Arboretum
[2]Institute of Plant Medicine, Kyungpook National University
[3]Research Planning and Coordination Team, Korea National Arboretum

For an ongoing systematic study of the Korean Vespidae, we analyzed the complete mitochondrial genome of a social wasp, *Vespula shidai* Ishikawa, Yamane & Wagnet, 1980 from the Korean Peninsula. This species is distributed in East Asia, including Korea, China, Japan and the Russian Far East. It can be distinguished from other species of the genus *Vespula* by having the distinct white stripes on the abdomen. The mitogenome is 17,527 bp in length, includes 13 protein-coding genes, 24 transfer RNA genes, and two ribosomal RNA genes. The overall base composition is 83.5% AT and 16.5% GC.

Key words: Hymenoptera, Vespidae, Mitochondrial genome, *Vespula shidai*

P122

A taxonomic study of the genus *Opesia* Robineau-Desvoidy (Diptera: Tachinidae) based on DNA barcoding and morphological analyses

Seung-Su Euo[1] and Ho-Yeon Han[2]
[1]Division of Forest Biodiversity, Korea National Arboretum
[2]Division of Biological Science and Technology, Yonsei University

The Genus *Opesia* Robineau-Desvoidy currently includes four valid species worldwide, of which three are known from Palaearctic region. We have recognized all the previously known Palaearctic species as well as a new species from Korea: *Opesia cana* (Meigen, 1824), *O. descendens* Herting, 1973, *O. grandis* (Egger, 1860), and *O.* sp. nov.-A. We conducted a DNA barcoding analysis of all these *Opesia* species as well as the sequences of *O. americana* and selected related species retrieved from BOLD Systems. We also provide body and genitalic photographs of the Palaearctic *Opesia* species. An identification key to the Palaearctic *Opesia* species is also presented.

Key words: Tachinidae, Phasiinae, *Opesia*, Taxonomy, DNA barcoding

P123

Discovery of an additional nematine sawfly, *Euura tibialis* (Newman) (Hymenoptera, Tenthredinidae) associated with false acacia in South Korea

Bia Park[1], Seulki Kim[2], Seungho Oh[3] and Gyeongmin Kim[1,4]
[1]Institute for Phylogenomics and Evolution, Kyungpook National University
[2]Department of Agricultural Biology, College of Agriculture and Life Sciences, Jeonbuk National University
[3]Environmental Research Institute, Yeungnam University
[4]Institute for Korean Herb-Bio Convergence Promotion, Kyungpook National University

The genus *Euura* Newman, 1837 is a group with high species diversity of the subfamily Nematinae, comprising over 650 species worldwide. It inhabits the Holarctic and Oriental regions, but more than 430 species are known in the Palaearctic region. This genus is currently separated from genus *Nematus* Panzer, 1801 only by genetic data, and the taxonomic problem has not been resolved due to the high morphological similarity with many species. Although a large number of species have been recorded and species diversity is highest in the Palaearctic region, only one species, *E. laeta* (Brischke, 1883), is known in South Korea.

Here, we newly add *E. tibialis* (Newman, 1837) to South Korean fauna. This species was described from Germany, but it is native to North America and is considered to be an invasive alien sawfly introduced into Europe and Japan. Its larva is related to false acacia trees without gall-inducing, whereas *E. laeta* induces bud gall on *Salix viminalis*. Adults of *E. tibialis* can also be easily distinguished morphologically from the latter by the predominantly yellow body.

Key words: exotic sawfly, Nematinae, *Robinia pseudoacacia*, Symphyta, Tenthredinoidea

P124

Status of inflow of Invasive ants into Korea

Min-Ji Lee, Heejo Lee, Nang-Hee Kim, Young-Gyu Ban, Dayeong Kim, Beom-jun Jang and Dong Eon Kim*

Invasive Alien Species Team, National Institute of Ecology, Seocheon, Korea

2017년 부산항에서 붉은불개미가 처음 발견된 이후 2019년 10월 「생물다양성 보전 및 이용에 관한 법률」 개정에 따라 외래생물 예찰과 대응이 강화되었다. 2017년부터 2022년까지 국내 자연생태계에서 발견된 외래개미는 *Linepithema humile, Paratrechina longicornis, Solenopsis geminata, Trichomyrmex destructor* 3아과 4속 4종, 수입 컨테이너에서 발견된 외래개미는 *Anoplolepis gracilipes, Camponotus compressus, Solenopsis invicta* 2아과 3속 3종이 발견되었다. 그 중에서 *Paratrechina longicornis*의 경우 주요 항만 주변으로 확산되고 있는 실정이다.

검색어: Invasive alien species, *Solenopsis invicta*, *Paratrechina longicornis*, Natural ecosystem

P125

Third Invasive Alien Species of *Anoplophora*: Establishment of *Anoplophora horsfieldii* in South Korea

Seunghyun Lee[1.2.3#], Junhyeong Choi[4#], Sangil Kim[5,6,7#], Hyunkyu Jang[8], Woong Choi[9], Woochan Kwon[10], Doyoon Kim[6], Jaedong Gim[11], Jonghyun Park[4], Sangwook Park[12], Seunggwan Shin[6,7], Seunghwan Lee[2,3] and Ming Bai[1*]

[1]Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences, China
[2]Research Institute for Agricultural and Life Sciences, Seoul National University, Korea
[3]Insect Biosystematics Laboratory, Seoul National University, Korea
[4]Division of Life Science, Korea University, Korea
[5]Museum of Comparative Zoology and Department of Organismic and Evolutionary Biology, Harvard University, USA
[6]School of Biological Sciences, Seoul National University, Korea
[7]Research Institute of Basic Sciences, Seoul National University, Korea
[8]1810-1502, 69, Sangil-ro, Bucheon, Korea
[9]305-403, Sechangnamsunhwan-ro, Namdong-gu, Incheon, Korea
[10]Division of Environmental Science and Ecological Engineering, Korea University, Korea
[11]Department of Applied Biology, College of Agriculture and Life Sciences, Chungnam National University, Korea
[12]Research Institute of Forest Insect Diversity, Korea

The genus *Anoplophora* is undoubtedly the most well-known longhorned beetle genera in pest science because of the notorious IASs, Asian longhorned beetle (ALB: *A. glabripennis*) and Citrus longhorned beetle (CLB: *A. chinensis*). In this paper, we report the third invasive alien species of the genus *Anoplophora* with the establishment of *Anoplophora horsfieldii* in South Korea. The species was first accidentally discovered in Jeju Island in September 2019. However, no additional specimens had been found since then and whether the species were established or intercepted by chance remains unknown until recently. With the discovery of multiple beetles, emergence holes, and an ovipositing female in 2022, we confirmed that the species was completely settled in Jeju Island. We hereby provide 1) the current status of *A. horsfieldii* in Jeju including their utilizing host plant, and the extent of damage, 2) the most probable origin of invasion by comparing the mtDNA of Korean samples with those from various regions across Southeast Asia, and 3) infer the phylogenetic position of *A. horsfieldii* within the genus using a single locus phylogeny of *Anoplophora*.

Key words: Cerambycidae, *Anoplophora*, Invasive alien species, South Korea, COI

[#]Equal contribution

P126

New hosts of two species of Ichneumonidae (Hymenoptera) 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 members of family Ichneumonidae usually attack other insects or spiders. Most of all, many ichneumon wasps are parasitoids of lepidopteran larvae or pupae. In this study, we report new host of two ichneumon species (*Apophua evanescens evanescens* and *Trathala flavoorbitalis*) from South Korea. A member of subfamily Banchinae, *A. evanescens e.*, is easily distinguished from other species follows; without areolet, simply convex clypeus, 2-4 tergites with oblique grooves and long second tergite than its apical width. The other species belonging to Cremastinae, *T. flavoorbitalis*, is also easily distinguished having visible sternite, complete occipital carina and entirely yellow body color. These species are discovered from *Cleora leucophaea* (Butler) (Lepidoptera: Geometridae) and *Pyrausta phoenicealis* (Hübner) (Lepidoptera: Crambidae) each other. The latter one is well known as pest of Labiatae, especially green perilla plants (*Perilla frutescens*). We provide diagnosis, plate and host record of two parasitoids, *A. evanescens e.* and *T. flavoorbitalis*.

Key words: Taxonomy, parasitic wasps, eastern palaearctic region

P127

New Records of 10 Species of the subfamily Ctenopelmatinae (Hymenoptera: Ichneumonidae) from 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 Ctenopelmatinae are one of the large families consist of approximately 1,500 species in 107 genera. In Korea 46 species in 23 genera have been recorded. the ctenopelmatine species are usually koinobiont, endoparasitiods of Hymenoptera (especially sawflies).

In this study, report 10 unrecorded species of Ctenopelmatinae from Korea. These species belong to eight genera (*Glyptorhaestus, Hadrodactylus*, *Lethades, Metopheltes, Perilissus, Pion, Sympherta* and *Xenoschesis*). Among them, two genera (*Metopheltes* and *Pion)* were newly recorded for the first time from Korean fauna. Diagnoses of those 10 species and illustrations of diagnostic characters are provided.

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

P128

Study on Spawning and Breeding Techniques of *Prosopocoilus astacoides blanchardi* (Coleoptera: Lucanidae)

Hyo-Ryeo Cho, Moon-Tae Choi, Jong-Eun Lee, Gug-In Han, Yu-Jin Kim and Ha-Seoung Park
Industrial Entomology Research, Chungcheongnam-do Agricultural Research and Extension Services

두점박이사슴벌레는 멸종위기야생생물2급으로 지정되어있으며, 국내 제주도에서 서식하고 있는 사슴벌레과의 곤충이다. 현재 무분별한 포획·채취를 방지하고 야생생물 복원 취지에 맞는 포획·채취 등의 행위 관리를 통해 「야생생물 보호 및 관리에 관한 법률」 로 보호받고 있다. 본 연구에서는 두점박이사슴벌레의 실내 사육을 통한 생활사와 사육배지 발효기간이 산란수에 미치는 영향을 알아보기 위하여 수행하였다. 산란된 알을 부화하여 실내 사육한 결과 유충 생육은 5일차 1령(0.01±0.00g), 10일차 2령(0.03±0.02g), 30일차 3령(0.19±0.11g)이었으며, 최대 90일경과시 4.06±0.95g으로 생육이 조사되었다. 또한 발효기간별 3주간 누적 산란수를 조사한 결과 2차 발효 20일 경과된 사육배지에서 평균 21±8.7마리로 산란량이 가장 높았다.

검색어: 두점박이사슴벌레, 사육, 산란

P129

Nano-injection technique for western flower thrips, *Frankliniella occidentalis*

Yun Seung-Hwan[1], Catherine Lee Raffin[2], Briana Elizabeth Price[2] and Man-Yeon Choi[2]
[1]Gyeonggi-do Agricultural Research and Extension Services
[2]USDA-ARS Horticultural Crop Research Unit, United State of America

Micro-injection techniques are valuable in entomological research as they allow for direct treatment of biological substance in the body of specimens at controlled volumes. Most of current micro-injections for live insects are limited to insects over 4 mm in size. Most of micro-injection methods utilize immobilization strategy that may affect specimen fitness and physiology. This conversion can cause inconclusive interpretation of phenotypic reactions post-injection. In this test, we elaborate an improved nano-volume injection technique for micro-insects (< 3 mm) using the western flower thrips, *Frankliniella occidentallis* (Thysanoptera: Thripidae), as a model. By constructing and using a modified vacuum system, injections were performed on live thrips, without anaesthetic and physical injury. A simple survivorship test in which the thrips were injected with 10 nl of pure water into the thorax or abdomen showed that thoracic injections yield similar survival rates to control thrips that were not injected, while abdominal injections severely limited survivorship. Here we suggest an integrative method that customizes the vacuum system, nano-injection tools, injection volume, and other specifications for live micro-insects (< 3 mm).

Key words: Nano-injector, no sedation, vaccum stage, thoratic injection, hemocoel delivery

P130

Study on attractants for the red imported fire ant, *Solenopsis invicta*

Gokulanathan Anandapadmanaban and Youngjin Park
Plant Quarantine Technology Center, Animal and Plant Quarantine Agency, Gimcheon 39660, Korea

The red imported fire ant (RIFA), *Solenopsis invicta*, is omnivore and native to South America. RIFA has been expanding their habitat through international trade routes to Asia and Oceania. In plant quarantine, RIFA surveillance is important to implement for preventing the risk of biological invasion to Korea. RIFA workers are female ants, so it is difficult to apply the sex pheromone in existing surveillance traps. This study is focusing to select attractants for RIFA trap. As an initial step, we have tested 5 pheromone compounds and 13 poisoning baits to RIFA and 2 native ants. Allofarnesene and 2,5-dimethyl-3-pyrazine in pheromone compounds and InTice in poisoning baits showed most effective rate of attraction to RIFA. Based on the results, selected 3 attractants show the possibility to use in RIFA traps for surveillance.

Key words: *Solenopsis invicta*, plant quarantine, surveillance, pheromone, trap, attractant

P131

Models for spring emergence prediction of the apricot seed wasp *Eurytoma maslovskii* (Hymenoptera: Eurytomidae) in South Korea

Hai Nam Nguyen, In-Jun Lee, Hyeock-Joo Kim and Ki-Jeong Hong*
Sunchon National University, Suncheon, Korea

Eurytoma maslovskii Nikol'skaya (Hymenoptera: Eurytomidae) is an important stone fruit pest. Control of the pest relies on application timing, which requires a reliable tool for predicting spring emergence. The most common approach in insect phenological modeling is based on temperature-dependent development and thermal bioparameters. However, not a lot is known regarding *E. maslovskii*. In the present study, we investigate the development of *E. maslovskii* after diapause breaks at various temperatures. The lower, upper temperature threshold and thermal constant of the species after diapause are estimated. The results confirm that the field emergence of *E. maslovskii* can be predicted by a model using accumulated degree days starting from 1 January, thereby providing an efficient tool for pest-control decision making.

Key words: cumulative flight; degree day; development rate; lower threshold; upper threshold, model selection.

P132

Improvement methods for imbalanced ecological data to enhance the modeling performance

Dae-Seong Lee and Young-Seuk Park
Department of Biology, Kyung Hee University, Republic of Korea

Most of the ecological data obtained through field surveys have the form of imbalanced data because most measured variables are skewed. These data cause bias in learning data during modeling for classification and prediction, and act as a major factor hindering the model performance. The purposes of this study are improvement of the modeling performance used these imbalanced ecological data and to find an improvement method suitable for ecological data. To do this, the change in modeling performance was evaluated and compared by applying several improvement methods of imbalanced data to the actual ecological data. The methods for improving imbalanced data used in this study were synthesis methods of over-sampling types using 1) the k-nearest neighbor, 2) smoothed bootstrap and 3) data-based polynomial regression with Monte-Carlo simulation.

Keywords: data bias, improving skewed data, over-sampling method

P133

Temperature and plant host mediated development parameters of *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae)

Rameswor Maharjan[1], Hwi Jong Yi[1], Seo Yeon Hong[1], Jeong Joon Ahn[2], Young Nam Yoon[1], Yun Woo Jang[1], Myoung Hee Lee[3], Jung In Kim[3] and Ki Do Park[1]
[1]Crop Production Technology Research Division, National Institute of Crop Science, RDA
[2]Research Institute of Climate Change and Agriculture, National Institute of Horticulture and Herbal Science, RDA
[3]Upland Crop Breeding Research Division, National Institute of Crop Science, RDA

The tobacco cutworm, *Spodoptera litura* is a serious and devastating polyphagous pest causing significant damages and economic losses to many important crops.Temperature (15, 20, 25, 27, 30, 35, and 40 °C) dependent developmental parameters and survival of *S. litura* were studied on the plant hosts (soybean and maize) and artificial diet. Stage-specific parameters such as lower developmental threshold and thermal constants were determined by linear and non-linear models (SSI). The total developmental time (egg-adult) decreased with increasing temperature from 15–35 °C on the plant hosts and artificial diet. The linear model estimated the lower temperature thresholds (T_{min}) and the thermal constants (K) for each life stage. Temperature and plant host also influenced the adults longevity. Estimated parameters can be used in predicting occurrence, number of generations and population dynamics of *S. litura*.

P134

Physiology estimation of the *Apis cerana koreana* honey bees to honey yield

Olga Frunze, Akongte Peter Njukang, Dongwon Kim, Eun-Jin Kang, Bo-Sun Park, Kyungmun Kim, Ju-Gyeong Kim, Daegeun Oh and Yong-Soo Choi*

Department of Agricultural Biology, National Institute of Agricultural Science, Wanju, 55365 Republic of Korea

The research shows the relation between practical methods to estimate the honey yield and the physiology of honey bees. The capacity of the honey stomach of the X-line compared to R-line *Apis cerana koreana* honey bees had significant differences and they were (42.60±12.82) and (37.68±11.53) μg on 1 bee respectively. Despite it, the honey productivity between X and R lines of honey bees during the Acacia honey production season in May 2022 was not found. The physiology evaluation is the simplest characteristic to test the superiority of honey bees for potential honey yield which carries out regardless of the weather.

Key words: honey bee, honey productivity, honey stomach

P135

Gene expression profiling of the worker bees according to the honey bee, *Apis mellifera*, swarming phenomenon

Kyungmun Kim, Bo-sun Park, Ju-gyeong Kim, Daegeun Oh, Eun-jin Kang, Dongwon Kim, Yong-Soo Choi and Su-bae Kim

Division of apiculture, National Institute of Agricultural Science, RDA, Wan-ju 55365, Republic of Korea

The honey bee, *Apis mellifera*, is a social insect that lives in the colony with the three different castes, a queen, workers and drones. Swarming phenomenon of the honey bee is division of the original colony into the two different colonies. It is one of the important social behavior that can be considered as a true reproduction of the honey bee. To investigate the gene expression changes that occur according to the flow of the honey bee swarming, transcriptome analysis of the worker bees from the pre-swarming colonies (PSC), post-swarrming colonies (swarming group: SG and remaining group: RG) and stabilized post-swarming colonies (stabilized swarming group: SSG and stabilized remaining-group: SRG) were conducted.

Key words: *Apis mellifera*, Honey bee, Social insect, Swarming, Transcriptome analysis

P136

Effects of pupa rearing condition (temperature) on queen weight at emergence raised initially from queenright and queenless colonies (*Apis mellifera* L.)

Akongte Peter Njukang[1,2], Olga Frunze[1], Kyungmun Kim[1], Ju-gyeong Kim[1], Daegeun Oh[1], Dongwon Kim[1], Eun-Jin Kang[1], Bo-sun Park[1] and Yong-Soo Choi[1*]

[1]Division of apiculture, National Institute of Agricultural Science, RDA, Wan-ju 55365, Republic of Korea
[2]Institute of Agricultural Research for Development (IRAD), PMB 25 Buea, Cameroon

Poor queens have been reported as the primary problem in a number of beekeeping operations, which ranks among the top reasons for colony failure and is attributed to body weight at emergence. Much is still undefined on pupa rearing condition especially ecological factors affecting queen weight at emergence. We reared <20 h old larvae in queenright and queenless colonies and transferred 50% each of the pupae into an incubator (34.7±0.42 ºC and 80±5 % RH). Highest queen weight (208.16±3.67mg) and low rate of emergence was measured from the incubator. Emergence rate was low in incubator while queen survival rate was high in the queenless colony. Increasing queen weight at emergence is beneficial to beekeepers for improving queen quality.

Key words: Queen quality, weight at emergence, pupa, ecological factor, honeybee queens

P137

Adaptability of the endangered dung beetle *Gymnopleurus mopsus* (Coleoptera: Scarabaeidae) in response to habitat migration

Hwang Kim and Young-Joong Kim

Research Center for Endangered species, National Institute of Ecology, South Korea

The dung beetle, *Gymnopleurus mopsus* is an endangered species that has not been observed in South Korea since 1970s. In the recovery process of endangered species, one of the most important factors for successful habitat settlement of populations is their ability to adapt to changing environments. In this study, we assessed whether Mongolian dung beetles introduced into South Korea can adapt to the domestic environmental conditions. Following hibernation, the adult *G. mopsus* showed reproductive behaviour between late May and early August, and the population increased about three times accordingly. Although a threefold population increase cannot be judged as a criterion for successful settlement, it does suggest the possibility of adaptation in the domestic environmental conditions.

Key words: endangered dung beetle, environmental adaptation, *Gymnopleurus mopsus*, restoration

P138

The Effect of suppressing Mites density in Shine musket vineyards by restoring the ecosystem in ChungCheongbuk-do

Myungkyu Song[1], Yeuseok Kwon[1], Jeongmoon Cha[1], Changwon Jeong[1], Eunjin So[1], Seokho Lee[1], InJae Kim[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('22)은 5,241ha 정도로 포도 면적 38.9%에 재배하는 1위 품종이다. 샤인머스켓 잎은 다른 품종과 달리 잎 뒷면에 잎털이 많아 응애 은신이 쉽고, 약제 방제시 잎털의 간섭으로 응애에 닿지 않아 방제가 어렵게 된다. 2022년 충북 샤인머스켓 포도원에서 응애류 발생생태를 조사한 결과 관행 가온재배에서 3월부터 살비제를 살포하더라도 5월 중순부터 개체수가 늘어나 8월 상순 52.6마리/잎의 최고밀도를 보였다. 그에 비해 유기재배 포도원에서는 살비제를 살포하지 않더라도 5월 하순 0.4마리/잎이 발견된 이후 8월 중순 6.8마리/잎의 최고밀도를 보였다. 이는 유기포도원에서 응애의 천적이 보호되어 응애 발생을 억제하기 때문으로 보인다. 관행 가온재배 포도원이지만 2020년까지 유기재배를 했던 포도원에서 2022년에 살충제를 사용하지 않고, 살비제를 5월 하순, 6월 중순 2회 살포해 수확기인 8월 상순 4.2마리/잎 밀도를 유지하였다. 따라서 관행 가온재배 포도원 중 응애 피해가 심한 농가에서 살충제 사용을 줄이고, 적기 살비제를 사용하면 경제적 피해를 줄일 수 있을 것으로 보인다.

검색어: 포도, 응애, 샤인머스켓, 발생, 생태

P139

Growth period by temperature of *Aphis nerii* Boyer De Fonscolombe(Hemiptera: Aphididae) occurring on medicinal crop *Cynanchum wilfordii* Hemsley

Sang-Ku Lee[1], Kyung Sook Han[1], Bueyong Park[2] and Sung Wook Jeon[3]

[1]Department of Herb Crop Resources, National Institute of Horticultural and Herbal Science, RDA

[2]R&D Coordination Division, Research Policy Bureau, RDA

[3]Corp Protection Division, National Institute of Agricultural Sciences, RDA

Cynanchum wilfordii Hemsley is a perennial tendril plant belonging to the family Apocynaceae, subfamily Asclepiadoideae, and it is distributed in sunny mountains and fields in Northeast Asia. Tubers grown for 2-3 years are used as herbal medicines in oriental medicine. As a major pest, *Aphis nerii* gathers on new branches or the underside of leaves from May and sucks on it. The belly is yellow and there is a black pattern at the bottom of the horn. *A. nerii* was studied at five constant temperatures (15.0, 20.0, 25.0, 30.0, and 35.0°C), 65±5% relative humidity (RH), and 14L:10D photoperiods. The growth period of nymphs by temperature was 15.2, 9.8, 5.1, 4.7, and 5.7 days, respectively, which shortened as the temperature increased, but became longer at 35°C. The lower threshold temperature of nymphs was 10.0°C and the thermal constant was 116.3DD. The survival period of adults by temperature was 10.1, 32.6, 30.5, 28.8, and 8.2 days, respectively.

Key words: *Aphis nerii*, *Cynanchum wilfordii*, Growth period, Survival period

P140

A pilot surveys on insect pests of three conifer trees from six high mountains in Korea

Jongok Lim[1], Dong Pyo Lyu[2], Sangwook Park[3], Kyoung-Yeon Cho[2], Haneul Yu[1], Jaewoo Yeom[1], Jungwoon Won[1], Seokmoo Kang[1], Suyeon Shin[1], Jun Gi Byeon[4] and Jong Cheol Yang[4]

[1]Department of Life and Environmental Sciences, Wonkwang University, Iksan, Korea
[2]Department Forest Landscape Architecture, Sangji University, Wonju, Korea
[3]Research Institute of Forest Insect Diversity, Namyangju, Korea
[4]Baekdudaegan Bioresources Conservation Department, Baekdudaegan National Arboretum, Bonghwa, Korea

Insects have various host ranges and they can cause serious economic and ecological damages to agriculture and forestry. Recently, many cases of damaged coniferous forest have reported in Korea and most of them caused by climate changes and the other reasons including insect pests. Korea Forest Service designated seven coniferous trees in high mountains as Endangered species because their distribution ranges are rapidly decreased by interruption of our activities and climate changes. In the present study, we carried out pilot surveys on insect pests of three coniferous trees: *Abies koreana, A. nephrolepis* and *Picea jezoensis* from six high mountains in Gangwon (three localities), Gyeongnam (one locality) and Jeonnam provinces (two localities) by Malaise trap and Lindgren funnel trap. Although we started this surveys from July in this year, we present the list of insect pests and discuss on the ecological importance of them.

Key words: *Abies koreana, Abies nephrolepis*, high mountain, insect pests, *Picea jezoensis*

P141

Occurrence of insect pests from urban parks in Honam regions

Jongok Lim[1], Haneul Yu[1], Jaewoo Yeom[1], Jeongwoon Won[1], Seokmoo Kang[1], Suyeon Shin[1], Ji-Hyun Park[2], Yonghwan Park[2] and Chansik Jung[2]

[1]Department of Life and Environmental Sciences, Wonkwang University, Iksan, Korea
[2]Forest Entomology and Pathology Division, National Institute of Forest Science, Seoul, Korea

Street trees refers to trees that are planted in harmony with roadsides in ubran areas, rural areas, mountains, coasts and riverside areas for national reforestations, landscape creation and pollution prevention. Recently, various insect pests frequently cause economic damage due to fragmentary planting of street trees, occurrence of exotic insects and introduction of foreign tree species into Korea. In this study, we investigated fauna of insect pests from main street tree species are planted in a total of six localities in Honam regions: three localities in Gwangju; two localities in Iksan; one locality in Gimje. As results of the present study, we provided a species list of insect pests for each main host (street tree) and damaged plants.

Key words: Honam, insect pest, street tree, urban park

P142

Soil ecosystem multifunctionality of gold mining area based on the energy flux

June Wee[1], Hyun-Gi Min[2], Yun-Sik Lee[2], Taewoo Kim[3], Yongeun Kim[2] and Kijong Cho[3]
[1]BK21 FOUR R&E Center for Environmental Science and Ecological Engineering, Seoul 02841, Korea
[2]O-Jeong Eco-Resilience Institute, Korea University, Seoul 02841, Korea
[3]Division of Environmental Science and Ecological Engineering, Korea University, Seoul 02841, Korea

For a better understanding of the role of the soil ecosystem, it is essential to consider the various functions provided by the soil ecosystem based on overall biodiversity. This recognition has increased the number of studies on the relationship between soil biodiversity and soil ecosystem multifunctionality (SEM), but there is still no consensus on how to evaluate this relationship. In this study, the SEM of five sites in the gold mining area was quantitatively assessed based on the energy flux of soil food web. The SEM of each site was highly correlated with the heavy metal concentrations of each site. This study will be used as scientific background for developing the assessment method on the overall soil ecosystem functions.

Key words: soil fauna, food web, ecosystem services, invertebrates, soil function

P143

First report of tropical fire ant, *Solenopsis geminata* (Fabricius, 1804) from South Korea

Nang-Hee Kim, Hee jo Lee, Dayeong Kim, Min-Ji Lee, Beom-jun Jang, Yeong-Gyu Ban and Dong Eon Kim*
Invasive Alien Species Team, National Institute of Ecology

The invasive alien species, *Solenopsis geminata* (Fabricius, 1804) is reported for the first time in Korea. The ants was found on the surface of the Roadside near Busan port. This detection was first occurrence in natural habitat. We provided distribution, illustration, morphological characteristics and management methods for this species.

검색어: Tropical fire ant, *Solenopsis geminata*, Invasive alien species, Busan port

P144

Characteristics of appearance of land insect resources in organic agricultural complexes for organic agro-ecosystems

Hong-Shik Nam, Choong-Bae Park, Jeong-Rae Cho, Sang-Gu Park, Min-Jae Kong, Jin-Kwan Son and Yangsoo Han
National Institute of Agriculture Sciences, RDA

This study was carried out to investigate the changes in insect diversity including biodiversity using biotop (e.g. eco-bridge, buffer zone) for the construction of DB for the ecological resource in the organic rice farming system. We collected samples from the organic rice paddy three times using sweeping and brandishing. As a result of examining insects, total 399 individuals from 9 orders, 46 families and 78 species were collected. The abundant families in the organic rice farming system were *Coleoptera*(21.8%), *Hemiptera*(21.8%), *Diptera*(19.2%), *Orthoptera* (11.5%), *Odonata*(9.0%), *Lepidotera*(9.0%), *Homoptera*(3.8%) and *Hymenoptera*(2.6%). And *Diptera*(28.6%), *Hemiptera*(19.0%), *Coleoptera*(14.3%), *Orthoptera*(14.3%) and *Odonata*(9.5%) have been observed repeatedly.

검색어: Land Insect, Agro-Ecosystem, Organic, Paddy Field

P145

Aspects of the occurrence of Planthopper Species in Rice Production Regions in Asia

Minjae Kong, Won-Young Kim, Bue-Yong Park, Ho-Jun Rim, Jum-Rae Cho and Hong-Hyun Park
Crop Protection Division, National Institute of Agricultural Sciences, RDA

Major pests occurring in rice production regions in Asia include *Nilaparvata lugens*, *Laodelphax stratellus*, and *Sogatella furcifera*. *Nilaparvata lugens* is a key pest that causes direct or indirect damage by viruses and causes economic losses of more than 3 million dollars annually in tropical and subtropical regions (Bae et al., 1995; RDA, 1998). Accordingly, this study was conducted to examine the pattern of occurrence of these migratory pests to protect rice production. In Korea, the occurrence of *Sogatella furcifera* started on June 28, 2022, and it was confirmed that the trend was gradually increasing. In the Chai Nat region of Thailand, there were some *Nilaparvata lugens* and *Sogatella furcifera*, and in the Chiang Rai region, *Sogatella furcifera* appeared from early February. The Tien Giang region of Vietnam had a large amount of *Nilaparvata lugens*, and it was confirmed that the Batalagoda region of Sri Lanka also had a large amount of *Nilaparvata lugens*. Continuous monitoring is necessary for the management of Planthopper Species in rice production regions in Asia, and it is important to exchange occurrence information among countries to prevent outbreaks of planthoppers.

Key words: *Laodelphax stratellus, Sogatella furcifera, Nilaparvata lugens*

P146

Presence of honeybee pathogen in apiraies during blooming Acacia (*Robinia qseudoacacia*) in 2021-2022, Korea

Ju-gyeong Kim, Kyungmun Kim, Daegeun Oh, Yong-Soo Choi, You-young Jo, Dongwon Kim, Bo-sun Park and Su-bae Kim
Division of apiculture, National Institute of Agricultural Science, RDA, Wan-ju 55365, Republic of Korea

The purpose of this study was to provide information on the change in disease occurrence during the blooming period of Acacia in 2021-2022. The honeybee samples were collected from 1 farm in Sejong City, 6 in Gyeonggi-do, 3 in Gangwon-do, 2 in Chungcheongbuk-do, 9 in Gyeongsangbuk-do, and 3 in Gyeongsangnam-do for a total of 24 farms. As a result using PCR analysis, black queen bee virus and *Nosema* sp. showed high infection rates for 2 years. There estimated to be chronically present in honeybees. In addition, in 2022, compared to last year, the infection rate of viral diseases increased (17-21%). It was estimated that some farms occured a lot of *Varroa destructor* during the blooming of the acacia in 2022.

Key words: Honeybee, Disease, Blooming, Acacia, Korea

P147

Confirming insect pathogenicity of *Metarhizium phasmatodeae* isolated from forest insect pest, *Ramulus mikado* (Phasmidae)

Seulki Kim, InJi Heo, Ha Young Cho, Jae Su Kim, Kui Jae Lee and Tae Young Shin
Department of Agricultural Biology, Jeonbuk National University, Jeonju, Republic of Korea

Stick insects are recently well-known forest insect pests, especially, damaged to broadleaf trees. From the last three years to the present sporadic insect pests have caused damage in various areas, especially in Gyeonggi-do and Seoul city. Currently, insect pesticide spraying is mainly used to control stick insects. This causes damage not only to target insect pests but also to other organisms, so other alternatives are needed. In this study, the entomopathogenic fungus was isolated from the cadaver of an adult *Ramulus mikado* supporting fungal conidiation. This fungus was identified as *Metarhizium phasmatodeae* by microscopic examination and genetic sequencing of the EF1-α regions. Following our result, this fungus showed pathogenicity only to stick insects. We provide fungal spores photo, host range, pathogenicity and molecular phylogenetic relationship.

Key words: stick insect, *Ramulus mikado,* entomopathogenic fungus, *Metarhizium, Metarhizium phasmatodeae*

P148

Proposal of yellow sticky roll trap for the control of thrips in pepper greenhouse

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

총채벌레는 세계적으로 약6,000종이 알려진 가운데, 이 중 약20종이 작물의 수확량과 상품성을 크게 떨어뜨릴 뿐만 아니라, 토마토반점위조바이러스(TSWV)와 같은 식물 바이러스의 매개체로서 농업해충으로 인식되고 있다. 현재 총채벌레 방제를 위해서 예찰용 평판 끈끈이트랩, 방충망, 화학농약, 그리고 최근에는 곤충병원성 미생물과 천적 뿌리이리응애를 지하부 총채벌레 방제용으로 활용되고 있으나, 고추와 같이 멀칭재배하는 경우 추가 투입의 한계가 있다. 본 연구에서는 지상부와 토양을 이동하는 총채벌레의 생태적 특성을 고려하여 예찰용 황색롤끈끈이트랩을 지재부에 설치함으로써 물리적으로 방제하는 방법을 제안하고자 한다. 황색롤끈끈이트랩 설치만으로도 45.3%의 방제효과를 보였으며, 유기농업자재를 추가로 살포했을 경우 무처리(최소방제) 대비 74.4%의 방제효과를 보였다.

검색어: 총채벌레, 황색끈끈이롤트랩, 친환경, 방제

P149

Evaluation of the susceptibility to abamectin in field population of the two-spotted spider mite, *Tetranychus urticae* Koch

Md Munir Mostafiz[1,2], Matabaro Joseph Malekera[2], Olha Muzhanovska[2] and Kyeong-Yeoll Lee[2,3]
[1]Department of Entomology, Kyungpook National University
[2]Department of Applied Biosciences, Kyungpook National University
[3]Sustainable Agriculture Research Center, Kyungpook National University

The two-spotted spider mite, *Tetranychus urticae* Koch, is one of the most damaging ornamental and horticultural plant pests. Control of this pest has been heavily dependent upon chemical acaricides. The aim of this study was to evaluate the susceptibility baseline of field populations of *T. urticae* to abamectin. A total of five field populations of *T. urticae* were collected in 2022 and the susceptibility of these populations to abamectin was determined in the laboratory using a direct spray application method. Variation of susceptibility was observed among populations with LC_{50} values ranging from 5.02 to 15.36 ppm for abamectin. Our results revealed that Damyang populations (LC_{50} = 5.02 ppm) were more susceptible to abamectin compared to Hadong (9.45 ppm), Iksan (10.33 ppm), Cheongdo (12.88 ppm), and Goryeong (15.36 ppm). The findings of our study will help future efforts to monitor *T. urticae* resistance to abamectin.

Key words: two-spotted spider mite, abamectin, resistance monitoring, insecticide resistance, susceptibility

P150

The effect of Chinese cabbage and tobacco as banker plants for natural enemy in tomato greenhouse

Yun Seung-Hwan, Sang-Youn Sim, Jong-In Choi, Jeong A Han, Dong-Hyeon Jo and Jung-Soo Park
Gyeonggi-do Agricultural Research and Extension Services, Hwaseong 18388, Korea

This experiment was carried out to test whether the banker plant can be used for *Orius laevigatus* and *Nesidiocoris tenuis*, the main natural enemies used in the tomato greenhouse. In the *O. laevigatus* case, aftrer inoculation with *Myzus persicae* on Chinese cabbage placed with moss rose together, and the density of *O. laevigatus* was investigated. The density of *O. leavigatus* was higher in Chinese cabbage compared to moss rose, and it seems that Chinese cabbage can be used as a banker plant for *O. leavigatus*. In the *N. tenuis* case, tobacco inoculated with *M. persicae* was placed with Chinese cabbage togather, and the density of *N. tenuis* was investigated. The density of *N. tenius* in tobacco was higher than that of Chinese cabbage, but it's density was similar between two banker plants in the tomato greenhouse. So Chinese cabbage and tobacco would be expected to be used as a banker plant of *N. tenuis*. In addition, tobacco showed an attractive effect on white fly. Therefore, tobacco would be expected to be used as a banker plant of *N. tenuis* and a trap plant of white fly.

검색어: banker plant, natural enemy, *Nesidiocoris tenuis*, *Orius laevigatus*

P151

Development of molecular based species identification tools for three major plant hoppers, BPH, SBPH, and WBPH (Hemiptera: Delphacidae)

Rahman Md Mafizur[1,2], Hwayeon Nam[1,3] and Juil Kim[1,4]
[1]Agriculture and Life Sciences Research Institute Kangwon National University
[2]Dept. of Biotechnology and Genetic Engineering, Faculty of Biological Science, Islamic University, Bangladesh
[3]Incheon International Airport Regional Office, Animal and Plant Quarantine Agency
[4]Program of Applied Biology, Division of Bio-resource Sciences, CALS, Kangwon National University

The planthoppers (Hemiptera: Delphacidae) are one of the primary sucking type pests in rice (mainly Southeast Asian countries including Korea) and are comprised of three morphologically similar species, including brown planthopper (BPH, *Nilaparvata lugens*, Stål), white-backed planthopper (WBPH, *Sogatella furcifera*, Horváth), and small brown planthopper (SBPH, *Laodelphax striatellus*, Fallén). Species diagnosis is important because insecticide resistance patterns and control strategies vary according to species, but accurate species diagnosis is not easy due to morphological similarities and sequence similarities. Here, multiplex PCR, which can analyze the composition and density of each species after mass collection in the field, and the Loop-Mediated Isothermal Amplification (LAMP) assay, which can diagnose within 1 hour without a separate DNA extraction process in the field, were developed based on the partial mitochondrial genome sequence. This simple and accurate multiplex PCR and LAMP assay can be used for intensive field monitoring of integrated management of these species.

Key words: Plant hopper, LAMP, Multiplex PCR, Mitochondrial genome

P152

Comparative transcriptome analysis of type II sex pheromone-related genes in two whitefly species, *Bemisia tabaci* and *Trialeurodes vaporariorum*

Wook Hyun Cha[1] and Dae-Weon Lee[1,2]
[1]Department of SmartBio, Kyungsung University
[2]Metabolomics Research Center for Functional Materials, Kyungsung University

Whiteflies are worldwide polyphagous pests that reduce crop yields through direct sucking or viral transmission. In this study, in order to identify understand the sex pheromone of whitefly, we identified genes related to type II sex pheromone via transcriptome analysis from two species of female adults, *Bemisia tabaci* and *Trialeurodes vaporariorum*. Approximately, 10.8Gb and 12.8Gb of data were obtained from *B. tabaci* and *T. vaporariorum*, respectively. Compared to *T. vaporariorum*, 2,590 contigs were up-regulated and 2,203 contigs were down-regulated in *B. tabaci*. Forty three cytochrome P450 monooxygenases (CYPs) and 6 odorant-binding proteins (OBPs) were found as type II sex pheromone-related genes from two species. *B. tabaci* revealed specific expression of 20 CYPs and two OBPs. These genes are likely to be involved in the species-specific sex pheromone biosynthesis.

Key words: sex pheromone, transcriptome, *Bemisia tabaci, Trialeurodes vaporariorum*

P153

Seasonal monitoring of the striped fruit flies, *Zeugodacus scutellata* using different forms of attractant, cuelure

Yong-Bong Lee and Youngjin Park
Plant Quarantine Technology Center, Animal and Plant Quarantine Agency, Gimcheon 39660, Korea

The striped fruit fly, *Zeugodacus scutellata* (Diptera: Tephritidae), is one of important pests in Cucurbitaceae plants. The cuelure is currently using with various forms for surveillance to the striped fruit fly including *Z. cucurbitae*, *Z. tau*, and *Bactrocera tryoni*, which are categorized as prohibited-quarantine pests in Korea. In this study, we investigated attraction effect on cuelure by 3 different forms as solid, liquid, and wax to striped fruit flies using the Steiner trap. The trap was placed in two Jeju and one Gyungbuk regions and the number of attracted flies by each cuelure form is monitored by every 2 weeks during 2021. There is significant difference on attraction effect to *Z. scutellata* by different form in two Jeju regions. Liquid and wax form of cuelure showed high attraction number to the *Z. scutellata* compared with solid form when flies were occurred with high population in July to August. However, there is no significant difference on attraction effect at low population in Juju and Gyungbuk by different forms. Based on field assay, liquid and wax form of cuelure are recommended for surveillance against *Z. scutellata*. Furthermore, these results also strongly indicates that cuelure is effective to quarantine pests including *Z. cucurbitae*, *Z. tau*, and *B.tryoni.*

Key words: *Zeugodacus scutellata*, cuelure, quarantine, surveillance, attractant

P154

Evaluation of soil microorganisms for the management of root-knot nematode

Jong-Hoon Kim, Byeong-Min Lee, Soo-Min Byeon and Kwang-Hee Son
Microbiome Convergence Research Center, Korea Research Institute of Bioscience and Biotechnology

Root-knot nematodes (RKNs) are plant parasitic nematodes that infect many plant species and cause significant economic losses worldwide. The development of novel biological control agents for the prevention and control of root-knot nematodes is becoming important. In this study, the possibility of nematicidal agents was confirmed by screening the soil microorganisms. Among them, it has been confirmed that *Burkholderia* spp. separated from domestic soil has the ability to control Root-knot nematodes. *In vitro* assay, it showed up to 80% mortality against four RKNs. The result of pot test showed that the RKN penetration and egg mass formation was significantly reduced in the treatment group compared to the control group. In addition, it was confirmed that plant growth increased about 7.6-fold compared to control groups. This suggests that it could be an effective biological control agent and a potent alternative to chemical nematicides.

Key words: Root-knot nematode, nematicidal activity, biological control, Plant growth

P155

Library Construction for microbial resources with plant parasitic nematode activity

Jong-Hoon Kim, Min-Kyoung Kang, Byeong-Min Lee, Dong-Jin Park, Soo-Min Byeon, Ho-Yong Park and Kwang-Hee Son
Microbiome Convergence Research Center, Korea Research Institute of Bioscience and Biotechnology

The annual loss alone is about 250 billion won, and the cost of nematodes for nematode control is also estimated at 70 billion won. Methods of controlling nematodes are largely divided into chemical control, physical control, and biological control. Of these, the chemical control effect is the greatest, but because pesticides can cause residual problems, organic farming materials are expensive and the efficacy of drugs is inferior, but many farmers are looking for organic farming materials. Therefore, we sought to find a resource for controlling nematodes from natural products. Among natural products, microorganisms produce a variety of beneficial secondary metabolites. In this study, potential nematode control microorganisms were searched from a microbial library, and the possibility of natural organic materials was suggested. In addition, through this study, we propose the value of microorganisms for the control of plant diseases in the future.

Key words: plant parasitic nematode, nematicidal activity, biological control, library construction

P156

Selection of organic agricultural materials for the control of black cutworm, *Agrotis ipsilon* (Lepidoptera: Noctuidae)

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

검거세미밤나방 3령 이상의 유충은 토양의 3~5cm 깊이에 서식하며 옥수수, 감자 등 80종 이상의 작물의 새싹과 줄기를 왕성하게 가해하는 습성이 있어 작물의 유묘기에 발생하면 막대한 경제적 손실을 불러오는 농업해충으로 알려져 있다. 이들의 방제를 위한 화학 살충제는 매우 효과적인 도구이지만 환경 오염, 천적 개체수의 파괴 및 살충제 저항성과 같은 심각한 부정적 결과를 초래한다. 이와 같은 부작용에 대한 대안으로 28종의 식물 유래 살충제(시판 유기농업자재)의 검거세미밤나방에 대한 살충활성을 조사하였다. 이 중 80% 이상의 높은 살충률을 보인 제품은 4종, 특히 화학농약 수준의 90% 이상의 살충률을 보인 제품도 1종을 선발하였다. 따라서 본 연구결과 생물농약으로써 50% 이상의 살충률을 보인 유기농업자재 제품 9종을 검거세미밤나방 방제용 농자재로 제안하고자 한다.

검색어: 검거세미밤나방, 유기농업자재, 살충활성, 방제

P157

Relationship of different drying conditions and functional healthful substances of the White-spotted Flower Chafer Larval (*Protaetia brevitarsis*)

Jong-Eun Lee, Mun-Tae Choi, Hyo-Ryeo Cho, GuK-In Han and Ha-Seung Park
Industrial Entomology Research, Chungcheongnam-do Agricultural Research and Extension Services

충남 지역특산품 중 인삼과 마늘의 농업부산물인 홍삼박과 흑마늘박 건조분말을 1일 절식한 흰점박이꽃무지 3령 유충의 배변유도용으로 3일간 급이하였고, 살처리 후 흰점박이꽃무지 유충의 건조 방법별 기능성 지표물질의 상관성을 구명하고자 수행하게 되었다. 살처리 및 건조 방법별 기능성 지표물질을 HPLC로 분석한 결과, 홍삼박을 섭식한 처리구 중 끓는 물에 60초 침지하여 열풍식 건조를 한 굼벵이 건조물에서 Saponin 함량이 50.75±1.97 mg $100g^{-1}$로 홍삼박 대비 1.78배 높게 나타났고, 흑마늘박을 섭식한 처리구에서도 열풍 건조를 통한 굼벵이 건조물에서 Pyruvate 함량이 45.93±0.05 mg $100g^{-1}$로 흑마늘박 대비 1.2배 높은 결과를 보였다. 또한 홍삼박 급여 후 유충 살처리 및 건조 조건별 Saponin 성분 특성 중 홍삼박은 Rb1 8.97 가 가장 많이 함유하고 있었던 반면, 열풍식 굼벵이에서는 피부보호 효능이 있는 F4 성분이 15.52 mg $100g^{-1}$를 보였고, -40℃로 살처리 후 동결건조식 굼벵이에서는 F4와 유사한 기능을 갖는 F1 7.87 mg $100g^{-1}$로 가장 높게 검출되었다. 그리고 흰점박이꽃무지 절식 유충의 배변 유도 및 기능성 향상을 위한 지역특산품 부산물을 급여한 굼벵이의 살처리 및 건조 조건별 관능평가 선호도 설문조사 결과, 끓는 물에 60초 침지하여 살처리 한 후 열풍건조를 하였을 때 풍미와 외형 및 색감에서 모두 우수하였을 뿐만 아니라 식미감을 떨어뜨리는 이취감 감소효과에도 가장 긍정적이었다.

검색어: 흰점박이꽃무지, 홍삼박, 흑마늘박, 사포닌, 피부르산

P158

A comparison of the rate of mating success between honeybee (*Apis mellifera* L.) lineages bred in the Wangdeung-do and Sik-do Island, Korea

Bo-Sun Park, Kyungmun Kim, Akongte Peter Njukang, Ju-Gyeong Kim, Daegeun Oh, Dongwon Kim, Su-Bae Kim, You-Young Jo and Young-Soo Choi
Division of Apiculture, Department of Agricultural Biology, National Institute of Agricultural Sciences, Korea

꿀벌의 유전자원을 보존 및 증식하기 위해서는 목표 계통에 다른 유전자가 오염이 되지 않도록 격리된 지역에서 이루어져야 한다. 본 실험은 양봉꿀벌을 육종하기 위하여 서해안 도서지역인 부안군 위도면 식도와 같은 지역 왕등도에서 격리육종을 수행하였으며, 이에 대한 교미 성공률을 분석하였다. 육종기간은 2021년부터 2022년까지 총 2년간 수행되었으며, 장원, C, D, V, F, A, AC, AD, FD, VD, CD, VF계통을 교미시켰다. 그 결과, V계통이 78.6%로 성공률이 가장 높았으며, C계통과 D계통은 각각 32.1%, 30.6%로 가장 낮은 성공률을 보였다. C계통의 경우, 21년 왕등도에서 같은 날 동일 조건으로 교미시킨 AC계통과 비교하였을 때, 각각 20%(n=20)와 80%(n=20)의 교미성공률을 보이며 확연한 차이를 나타냈다. 장소별로는 왕등도와 식도의 교미율은 각각 60.2%와 62.3%로 큰 차이를 나타내지 않았으나, 교미성공률의 편차는 각각 ±31.1, ±17로 식도가 작게 나타났다. 식도는 아까시나무, 유채꽃 등의 밀원수가 풍부한 반면, 왕등도의 식생은 주로 조릿대가 우점하여 밀원수가 식도에 비해서는 부족한 실정이다. 밀원수의 조건이 극명하게 차이남에도 불구하고 장소별 교미성공률에는 차이가 나지 않았다. 이를 통하여 밀원수의 분포는 교미 성공률에 영향을 미치지 않는다는 추측을 할 수 있었으며, 이에 대한 추가적인 연구를 통하여 도서지역 육종후보지 선정에 기초자료로 활용할 수 있을 것으로 판단된다.

검색어: 꿀벌육종, 격리육종, 자연교미, 양봉꿀벌, 유전자원

P159

Anti-inflammatory activity of Extracts from *cordyceps militaris* cultivated as hosts of *Tenebrio molitor* and *Gryllus bimaculatus*

Eunsun Kim, Bonwoo Koo, Kwanho Park, Ji Yeong Park, Kyu-won Kwak and Yongsoon Kim*
National Institute of Agricultural Sciences, RDA, Wanju, Korea

Cordyceps militaris is a fungus belonging to the Class Ascomycetes, Order Clavicipitales, and Family Clavicipitaceae, which are mostly parasitic in insects and form the fruit body from host insects. We measured NO production inhibition ability by inducing NO synthetics in RAW 264.7 cells to confirm the anti-inflammatory effects of the fruit body and culture medium formed from major industrial insects, mealworm(*Tenebrio molitor*) and two-spotted cricket(*Gryllus bimaculatus*). As a result, it was confirmed that the fruit body of *T. molitor* and culture medium of *G. bimaculatus* had NO synthesis inhibitory effect and no cytotoxicity. This study was conducted to promote the consumption of industrial insects and contribute to farm income.

Key words: Industrial insects, *Cordyceps militaris*, anti-inflammatory effects

P160

Genetic diversity of *Gryllus bimaculatus* De Geer, 1773(Orthoptera, Gryllidae) in South Korea

Gyu-Dong Chang, Su Hyun Yum, Sangmin Ji, Sun Young Kim and Jeong-Hun Song
Department of Agricultural Biology, National Institute of Agricultural Sciences

Gryllus bimaculatus (GB), as known as Ssang-byeol-gwi-ttu-ra-mi, has being important role in the Korean insect industry, especially in edible insects market. Because of this importance, physiological studies on GB has been mainly focused on mass rearing techniques, but there is no comprehensive study of the genetic diversity within the Korean GB population. We here examined how many genetically different haplotypes distributed in the reared GB collected from five insect farms, two national insect rearing facilities with 12 foreign GB using mitochondrial *COI* gene sequences (DNA barcoding region). As a results, six haplotypes were detected from 111 specimens with low intraspecific genetic distance (~1.8%). Among them the most dominant haplotype was overwhelmingly detected as haplotype 1 (H1), consisting of all Korean specimens and four specimens from China, Indonesia, and Germany. Based on this study, the reason for the low genetic diversity of Korean GB is thought to be that the GB population imported for feed from Japan in the early 2000s became a maternal group and then spread throughout cricket farms in Korea.

Key words: *Gryllus bimaculatus*, genetic diversity, *COI*, haplotype, Korea

P161

Anti-inflammatory effect of *Hermetia illucens* larvae extract

Ji Yeong Park†, Bonwoo Koo, Eunsun Kim, Yong-Soon Kim and Kwanho Park
Industrial Insect and Sericulture Division, Department of Agricultural Biology, National Institute of Agricultural Sciences, RDA, Wanju 55365, Korea

Inflammation is an immune response that protects the body from damage caused by external stimulation, and it is an important system for reducing tissue damage and maintaining homeostasis. However, when it is excessively activated, it may act as a factor for the onset of various diseases. In this study, we confirmed the anti-inflammatory effect of *Hermetia illucens* larvae ethanol extract (HIE) and confirmed its influence on pro-inflammatory factors. The NO expression was inhibited by 41.74±8.99% at HIE 400 μg/ml when compared to LPS treatment. The expression of TNF-α, IL-1β and IL-6 was suppressed by 76.60±2.04%, 67.06±2.36% and 96.56±0.41% at HIE 400 μg/ml when compared with the LPS treatment. Therefore, it was confirmed that HIE has the effect of suppressing the expression of pro-inflammatory cytokines. And the protein expression of iNOS and COX-2 were confirmed to be suppressed by 93.58±1.42% and 96.42±0.82% with HIE 400 ug/ml when compared with LPS treatment. Thus, ethanol extract of *Hermetia illucens* larvae (HIE) is expected to have high utility value as an anti-inflammatory material.

Key words: *Hermetia illucens*, Anti-imflammatory, COX-2

P162

Development of SNP-based CAPS markers distinguishing four fruit flies (*Bactrocera scutellata*, *B.depressa, B.cucurbitae,* and *B.dorsalis*)

Jeong Oh Yang[1], Ho-Jin Yoon[1], Hyun Ji Cho[2], Ji-su Kim[3], Yang-Jae Kang[4] and Kil-Hyun Kim[5*]

[1]Yeongnam Regional Office, Animal and Plant Quarantine Agency, Busan 48943, Korea

[2]Gimhae District Office, Animal and Plant Quarantine Agency, Gimhae, 50800, Korea

3Sokcho District Office, Animal and Plant Quarantine Agency, Sokcho 24882, Korea

[4]Division of Life Science Department at Gyeongsang National University, Jinju 52828, Korea

[5]Incheon International Airport regional office, Animal and Plant Quarantine Agency, Incheon, 22382, Korea

Over the 25 years, Seven exotic *Bactrocera* species have been detected by quarantine procedure, none of them has been established in Korea. To prevent the possibility of invasion by exotic fruit fly species, about 1,000 surveillance traps are set up and maintained from April to November of each year. Traps are placed in the canopy of fruit fly host plants near the airport, bay, and areas with high concentration of foreigners. The quarantine inspectors check the steiner traps at 2-weekly intervals. Sometimes, two *Bactrocera* species, the striped fruit fly(*B.scutellata*) and the pumpkin fruit fly(*B.depressa*) are known to naturally occur throughout Korea, were captured in the steiner traps for the oriental fruit fly(*B.dorsalis*) and the melon fruit fly(*B.cucurbitae*), respcetively. It is difficult to distinguish among four fruit flies because of similar morphological characteristics and this needs highly trained experts for the identification. To overcome this diagnosis method, we performed whole genome sequencing of collected *B.scutellata* and *B.depressa*. The reference genome for *B.scutellata* was perfectly matched with reads from *B.cucurbitae*, and 90% of paired reads were correctly paired. Based on the next generation sequencing data, we developed Cleaved Amplified Polymorphic Sequences(CAPS) markers as key genes to distinguish four fruit flies in a few hours. This would enable efficient in-and-out for the quarantine procedure and reduce the importing delays. It will be a basic and essential marker not only rapid identification of *B.scutellata*, *B.depressa, B.cucrbitae*, and *B.dorsalis* but also environmental protection of Korea from fruit flies.

Key words: exotic fruit fly, whole genome sequencing, CAPS,

P163

The reoccurrence case of the tropical bed bug *Cimex hemipterus* (Heteroptera: Cimicidae) with *super-kdr* mutations in the Republic of Korea

Susie Cho[1], E-hyun Shin[2], Ho Cheol Ju[2], Eui Seok Jeong[2], Si Hyeock Lee[1,3] and Ju Hyeon Kim[4*]

[1]Department of Agricultural Biotechnology, College of Agriculture and Life Science, Seoul National University, 08826 Seoul, South Korea

[2]Research Institute, Korea Pest Control Association, 08501 Seoul, South Korea

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

[4]Department of Tropical Medicine and Parasitology, Seoul National University College of Medicine, 03080 Seoul, South Korea

Infestations of the common bed bug, *Cimex lectularius* (L.) and the tropical bed bug, *Cimex hemipterus* (F.) (Hemiptera: Cimicidae) have resurfaced globally in the last two decades, due to increased international travel and trade in conjuction with the development of pesticide resistance. *C. hemipterus* has recently been detected in temperate locations, indicating the possibility of its spread outside of tropical areas. Since its description in 1934, *Cimex hemipterus* has not been officially recorded in Korea. Here, we report the first reoccurrence case of *C. hemipterus* in Korea based on morphological and molecualr identification. *Super-kdr* mutations (M918I and L1014F) related with pyrethroid resistance were determined by partial sequencing of the voltage-sensitive sodium channel gene. This case report serves as a warning to intensify the bed bug surveillance system in Korea regarding the existence of *C. hemipterus* and to prepare effective alternative insecticides to pyrethroids.

Key words: *Cimex hemipterus*, bed bug, mtCOI, voltage-sensitive sodium channel, insecticide resistance

P164

Molecular identification of the fall armyworm, *Spodoptera frugiperda* (Smith) in South Korea

Gwan-Seok Lee, Da-Gyeong Jeong, In Hong Jeong, Meeja Seo and Hong-Hyeon Park

Crop Protection Division, National Institute of Agricultural Sciences, RDA

The fall armyworm, *Spodoptera frugiperda* (Smith), first found in 2019 has become an important migratory insect pests in South Korea. Corn was the most affected crop occasionally with severe damage. Besides of morphological identification, the populations of *S. frugiperda* in South Korea were genetically identified using triosephosphate isomerase (*Tpi*) genes and mtDNA cytochrome oxidase subunit I (*COI*). During four years (2019-2022), *Tpi* gene analysis shows that all larval or adult samples collected nationwide belong to sub-population of "corn strain". Mitochondrial *COI* gene analysis, however, indicates that the ratio of *COI* genetic groups, COI-A and COI-B, has been changed, of which COI-B group increased from 5% in 2019 to about 40% in 2022.

Key words: *Spodoptera frugiperda*, molecular identification, migration, Korea

P165

Colour variation of vertex and pronotum of *Bothrogonia ferruginea* (Hemiptera: Auchenorrhyncha: Cicadellidae: Cicadellinae)

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 *Bothrogonia* Melichar, 1926 belongs to the tribe Cicadellini under the subfamily Cicadellinae (Hemiptera: Auchenorhyncha: Cicadellidae). A total of 47 species have been recorded in the whole world. While in Korea, only one species, *Bothrogonia ferruginea* has been recorded so far. Some species of this genus can cause injuries to plant species such as pear tree and various berries. The species of *Bothrogonia* are known to have broad colouration of vertex or pronotum, and they are very similar in appearance which make it difficult to be identified by morphological characters only. In this study, we provide a description and illustration of the variations.

Key words: Cicadellinae, variations, taxonomy, *Bothrogonia*

P166

Genetic diversity and population structure of *Maruca vitrata* (Fabricius) in India

Rashmi M. Mahalle[1,2], Snehel Chakravarty[2] and Chandra P. Srivastava[2]
[1]Institute of Agricultural Sciences, Chungnam National University, Daejeon, Republic of Korea
[2]Department of Entomology and Agricultural Zoology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 221005, India

Maruca vitrata is one of the major biotic constraints for pigeonpea production in India. A detailed understanding of the population genetic structure of this pest species in the country is essential to design better strategies for its management. Here, we explored the genetic diversity among *M. vitrata* populations collected from diverse agro-ecologies using mitochondrial cytochrome c oxidase I (*COX-1*) gene. The study showed a low number of segregating sites (10), haplotypes (13), nucleotide diversity (0.00136) and overall mean genetic distance (0.0013) among the populations. The negative values of neutrality tests supported the demographic expansion theory in Indian *M. vitrata*. Analysis of the molecular variance revealed that variations among populations or groups were only 13.91%. The pairwise genetic differentiation was also found to be low to moderate between most of the populations. Further isolation by distance analysis using Mantel's test (R^2 = 0.0024, p = 0.280) indicated that geographical distance did not significantly contribute to the genetic differentiation. Both neighbour-joining tree and the haplotype network also showed that clustering of the haplotypes was independent of the geographical location. There is a possible occurrence of stable inherited gene flow among populations, thereby reducing genetic variation of *M. vitrata* in India.

Key words: *COX-1* gene, diversity, haplotype, *Maruca vitrata*, pigeonpea, phylogeny

P167

Newly recorded species of the genus *Latuspina* Monzen (Hymenoptera: Cynipidae: Cynipini) from 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

The genus *Latuspina* Monzen, one of the Cynipini (Hymenoptera: Cynipidae) genera, and it contains of nine species in the Palaearctic and Oriental region. In Korea, only two species are known to date; *L. abemakiphila, L. kofuensis*. We herein describe and illustrate a newly recorded species of the genus from Korea.

Key words: Hymenoptera, Cynipidae, Oak gall wasp

P168

COI Barcoding and Taxanomic Study of Korean Cyclostome Wasps (Hymenoptera: Braconidae)

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

Most parasitic insects are known as hymenopterans, of which main hosts are Diptera, Coleoptera and Lepidoptera. Among them, the braconidae family has about 21,000 species recorded worldwide, subdivided to more than 40 subfamilies, occurring broadly in tropical, temperate or dry habitats. Cyclostome braconids with concave clypeus are a monophyletic group of parasitic wasps, characterized by a various parasitic strategy in koinobiont or idiobiont ecto/endo-parasitoid. It also includes five relatively well-known and species-rich subfamilies (Alysiinae, Braconinae, Doryctinae, Opiinae and Rogadinae), comprising with more or less 15 subfamilies, but comparison of morphological features and phylogenetic relationships of family-level of cyclostome braconids remain unclear even although previous molecular phylogenetics were performed. In this study, for 157 morphospecies samples as MOTU, we phylogenetically compare and analyze the posterior probability values of the three results, ABGD, bPTP and GMYC, in order to evaluate and delimit species for the relationship of cyclostrome braconids based on COI barcoding analysis.

Key words: Natural enemy, Phylogeny, Tribes, Taxonomy, Host range

P169

First record of a parasitoid wasp, *Neastymachus japonicus* (Chalcidoidea: Encyrtidae) from South Korea

Yeonghyeok Yu and Hyojoong Kim
Kunsan National University, Gunsan, Republic of Korea

The genus *Neastymachus japonicus*, 1915 belonging to the family Encyrtidae is known to include 20 species worldwide. This genus is a perparasitic wasp on scale insects. *Neastymachus japonicus* Tachikawa, 1970 is recognized for the first time in South Korea, of which specimens were firstly collected from Seocheon, South Korea. *Neastymachus japonicus* is a parasitic *Nipponaclerda biwakoensis*, based on *Phragmites australis*. Descriptions, diagnosis, distribution and illustration are provided.

Key words: Hymenoptera, Natural enemy , Taxonomy, Unrecorded species

P170

A newly record of the genus *Ephedrus* (Hymenoptera, Braconidae, Aphidiinae) from South Korea

Sangjin Kim[1], Cornelis van Achterberg[2], Ju-Hyeong Sohn[1] and Hyojoong Kim[1]
[1]Kunsan National University, Gunsan, Republic of Korea
[2]Zhejiang University, Hangzhou, China / State Key Laboratory of Rice Biology and Ministry of Agriculture, Hangzhou, China

The genus *Ephedrus* Haliday, 1833 is a taxon of Aphidiinae (Hymenoptera: Braconidae), consisting of 49 species in the worldwide. To date, only 5 *Ephedrus* species have been recorded in South Korea. In this study, newly recorded species, E. lacertosus, is reported. In addition, their descriptions and illustration are provided.

Key words: Ephedrini, unrecorded species, DNA barcoding, parasitoid wasps, systematics, taxonomy

P171

The first record of the Genus *Caelius* Lewis, 1895(Coleoptera: Scarabaeidae: Aegialiinae) from South Korea

Gyu Young Han, A Young Kim and Il-Kwon Kim
Division of Forest Biodiversity, Korea National Arboretum

Caelius Lewis, 1895 contained only five species worldwide. Most species mainly distributed in the Nearctic region. In the neighboring countries of Korea, only one species, *Caelius denticollis* Lewis, 1895, was recorded in Japan. In this study, the genus *Caelius* was newly recognized from South Korea, with *Caelius denticollis* Lewis, 1895. The description and images of adults are provided. Also, a key to the Korean genus in Aegialiinae is presented.

Key words: *Caelius,* Aegialiinae, newly record, Korea

P172

Review of *Stigmella* leaf-mining moth (Lepidoptera, Nepticulidae) feeding on Oak (*Quercus* spp.) in South Korea, with a newly recorded species

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

The present study reviewed the recent findings of nepticulid species feeding on Oak leaves from South Korea, in particular focused on the genus *Stigmella* Schrank, 1802, which contains six species: *S. aladina*, *S. dentatae*, *S. fumida*, *S.kurokoi, S. omelkoi* and *S. clisiotophora*. Among them, *S. clisiotophora* was new to South Korean insect fauna. In addition, female *S. fumida* and male *S. aladina,* which were not previously unknown to science, were described in the present study, and the images of leaf-mines for each species were given for the first time. The brief morphological diagnosis includes host plants and leaf-mines of each species. A check list is also provided along with a key to the Oak feeding *Stigmella* species in South Korea.

Key words: Lepidoptera, Nepticulidae, *Stigmella*, Fagaceae, newly record, Korea

P173

New record of *Nematus tibialis* Newman, 1837 (Hymenoptera: Tenthredinidae) from South Korea

Jae Hyeon Lee[1], HyoJin Jeong[1], Hye-Rin Lee[2], Jin-kyung Choi[3], Gwan-Seok Lee[4], Gi-Myeon Kwon[5], Deok-Seo Ku[1] , Tae-Ho An[7] and Won-Hoon Lee[6]

[1]The Science Museum of Natural Enemies, Geochang, Korea

[2]Restoration Research Team (Insects), Division of Restoration Research, National Institute of Ecology, Yeongyang , Korea

[3]Department of Science Education, Daegu National University of Education, Daegu , Korea

[4]Disaster Management Division, Rural Development Administration (RDA), Jeonju, Korea

[5]Biological Utilization Institute, Andong, Korea

[6]Department of Plant Medicine and Institute of Agriculture & Life Science, Gyeongsang National University, Jinju, Korea

[7]Jinju Girls' High School, Jinju, Korea

In this study, the subfamliy Nematinae, Nematus Tibialis Newman, 1837, is firstly reported in South Korea. Photographs and diagnosis of the species are provided. It also provides morphological variations, life history, and distribution of species.

Key words: Hymenoptera, Nematinae, *Nematus tibialis*, New record, South Korea

P174

Two new species of the genus *Cratospila* Foester (Hymenoptera, Braconidae, Alysiinae) from South Korea

Ju-Hyeong Sohn[1], Cornelis van Achterberg[2], Yeonghyeok Yu[1] and Hyojoong Kim[1]

[1]Kunsan National University, Gunsan, Republic of Korea

[2]Zhejiang University, Hangzhou, China / State Key Laboratory of Rice Biology and Ministry of Agriculture, Hangzhou, China

Two new species of the genus *Cratospila* Foerster, 1863 (Braconidae: Alysiinae), *Cratospila albosignata* sp. nov. and *C. longivena* sp. nov., are described and illustrated from South Korea. In addition, the DNA barcode region of the mitochondrial cytochrome *c* oxidase subunit I (COI) of both species has been sequenced. *Alysia ponerola* Papp, 2009 which was recorded from North Korea is transfered in *Cratospila* (*C. ponerola* (Papp, 2009) comb. nov.).

Key words: Alysiini, COI, Hymenoptera, new combination, new record, new species, taxonomy

P175

Comparative characteristics of complete mitochondrial genome of *Carpophilus obsoletus*

Min Jee Kim[1*], Sol Kang[1], Sol-Moon Na[2], Jin Sik Park[1] and Iksoo Kim[3]
[1]Honam Regional Office, Animal and Plant Quarantine Agency
[2]Yeongnam Regional Office, Animal and Plant Quarantine Agency
[3]Department of Applied Biology, Chonnam National University

The dried-fruit beetles, *Carpophilus* (Coleoptera: Nitidulidae), are worldwide pests of fruits, frequently detected during the quarantine process of dried distillers grains with solubles (DDGS) and wood pellet and some species are treated as Managed pest for protecting us agri environment in South Korea. Moreover, they are identifiable based on several morphological keys, but are difficult to diagnose promptly as species level if they are detected as immature stages such as larvae and pupae. In order to overcome such difficulty and complement identification method, thus, alternative diagnostics technique would be necessary. In this study, we sequenced and characterized complete mitochondrial genome (mitogenome) of *C. obsoletus* and are in the middle of scrutinizing the genomic characteristics of the family.

Key words: sap-feeding beetle, immature stage, molecular diagnostics, qurantine pest

P176

Taxonomic study of the genus *Agriotypus* Curtis, 1832 (Hymenoptera, Ichneumonidae, Agriotypinae) 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

The subfamily Agriotypinae is a small group of aquatic parasitoid wasps which is known as parasitize trichopteran pupae and prepupae in fast-running water. *Agriotypus* Curtis is the monotypic genus in this subfamily Agriotypinae (Hymenoptera, Ichneumonidae), comprising 16 species from the Palaearctic and Oriental Regions. In this study, two new species, *A.* **sp. n**. 1 and *A*. **sp. n.** 2 are described. We also provide diagnoses of adults and larva with photographs and an identification key to South Korean species.

Key words: *Agriotypus*, Aquatic wasp, DNA barcode, taxonomy, Trichoptera.

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government(MSIT) (NRF-2021R1F1A1052395).

P177

New record of fungus weevils (Coleoptera, Anthribidae) to Korean Korean peninsula

Sangwook Park and Young-Eun Han
Research Institute of Forest Insect Diversity, Namyangju, South Korea

소바구미과의 종들은 일부 포식성인 종과 유충이 식물의 열매를 가해하는 종들을 제외하고는 주로 고사목에서 자라는 균류를 먹고 생활한다. 현재까지 우리나라에는 총 47종의 소바구미과에 속하는 종들이 기록되어 있다. 최근 흑산도 및 제주도 등 남부 도서지역에서 곤충상 조사를 진행하던 중, 소바구미과 (Anthribidae)의 1 미기록종 (*Dendropemon nagaoi* (Morimoto, 1972),) 1 신종 (*Xanthoderopygus jejuensis* Sp. nov.)을 발견하였다. 이들에 대한 형태 및 간략한 정보를 제공하고자 한다.

검색어: *Dendropemon nagaoi, Xanthoderopygus jejuensis*, Anthribidae, 소바구미과, 미기록종, 신종

*본 연구는 환경부의 재원으로 국립생물자원관의 지원을 받아 수행하였습니다 (NIBR202002205, NIBR202203201).

P178

Comparison between recently introduced bark and ambrosia beetles and closely related species

Sangwook Park[1], Youngjin Park[2] and Young-Eun Han[1]
[1]Research Institute of Forest Insect Diversity, Namyangju, South Korea
[2]Plant Quarantine Technology Center, Animal and Plant Quarantine Agency, Gimcheon, South Korea

2020년대에 들어오면서 과거에 국내에서 알려지지 않았던 나무좀아과 또는 긴나무좀아과에 속하는 해충들의 국내 분포가 밝혀지고 있다. 이들은 그 분포가 정확하게 알려지지 않았던 미기록종과 목재 등의 수입 또는 선박에 편승하여 국내에 정착하게 된 침입종으로 구분할 수 있다. 최근 국내에도 분포하는 것으로 알려진 닮은왕나무좀 (*Euwallacea interjectus* (Blandford)은 일본과 중국에서 처음 보고된 종으로 최근 일본에서는 무화과나무 (*Ficus carica*)의 시들음병 문제를 야기하고 있다. 왕털소나무좀 (*Hylurgus ligniperda* (Fabricius))은 독일에서 처음 보고되었으며, 유라시아가 원산지로 아메리카 대륙 및 오세아니아에 확산되었다. 이 종은 일본 및 중국에도 침입한 종으로 여겨지고 있으며, 이들의 생물지리학적 분포 및 확산 등에 대한 연구가 진행되고 있다. 본 연구에서는 최근 국내에 분포가 보고된 종 가운데에 검역과 관련된 나무좀 및 긴나무좀의 목록과 이들의 현재 국내 분포상황 및 근연종에 대한 간략한 정보를 제공하고자 한다.

검색어: 닮은왕나무좀, 왕털소나무좀, 나무좀아과, 긴나무좀아과, 근연종, 침입종

*본 연구는 농림축산검역본부의 지원을 받아 수행하였습니다(PQ20170B013).

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External characters for the identificaion between *Euwallacea validus* and *E. interjectus*

Sangwook Park[1], Youngjin Park[2] and Young-Eun Han[1]
[1]Research Institute of Forest Insect Diversity, Namyangju, South Korea
[2]Plant Quarantine Technology Center, Animal and Plant Quarantine Agency, Gimcheon, South Korea

2020년 우리나라의 제주도에 분포하는 것으로 기록된 닮은왕나무좀 (*Euwallacea interjectus* (Blandford, 1894)) 가 올해 여러 곳자왈 지대를 포함하여, 한라산 둘레를 따라 넓게 분포하는 것이 확인되었다. 국내에 분포하는 *Euwallacea* 속의 본 종을 포함하여, 1930년 제주도에서 기록되었으나 그 이후 채집기록이 없는 애나무좀 (*E. praevius* (Blandford, 1894)) 및 전국에 분포하고 있는 가문비왕나무좀 (*E. validus* (Blandford, 1874)) 등 총 3종이 기록되어 있다. 가문비왕나무좀은 주로 소나무 등의 침엽수 고사목에서 확인되는 것에 반하여, 닮은왕나무좀은 활엽수를 주로 가해하는데 올해 생강나무, 붉가시나무의 생목에 침입하여 고사시키는 것이 확인되었으며, 제주도에서 점차 그 분포가 넓어지고 있고, 이후 내륙지방에도 확산될 가능성이 있다. 따라서, 닮은왕나무좀의 활엽수에 대한 피해 양상을 보고하여 추가 연구에 도움이 되고자 하며, 국내에 분포하는 것으로 알려진 *Euwallacea*속 3종을 쉽게 구분하는 형질을 제공하고자 한다.

검색어: 닮은왕나무좀, 제주도, *Euwallacea interjectus*, *E. praevius*, *E. validus*

*본 연구는 농림축산검역본부의 지원을 받아 수행하였습니다(PQ20170B013).

P180

Four newly recorded species of the genus *Microplitis* Förster (Hymenoptera: Braconidae: Microgastrinae) from Korea

Hye-Rin Lee[1,2], Deok-seo Ku[3] and Bong-Kyu Byun[2]
[1]Restoration Research Team(Insects), National Institute of Ecology
[2]Department of Biological Science & Biotechnology, Hannam University
[3]The Science Museum of Natural Enemies

Microplitis is cosmopolitan genus of the subfamily Microgastrinae. This genus comprises more than 192 described species in the world (Fernandez-Triana et al. 2020). A number of *Microplitis* are solitary endoparasitoids of Macrolepidoptera larvae: Sphingidae, Noctuidae and Geometridae.

To date, 20 Korean species were recorded by Papp (1987), Belokobylskij (2012) and Choi & Kim (2018). In this study, four species of *Microplitis* are reported for the first time from Korea. Diagnosis, distribution and host information are provided for each species.

Key words: *Microplitis*, Braconidae, Hymenoptera, Korea, Parasitic wasp

P181

One new species of the genus *Dayus* Mahmood (Hemiptera: Auchenorrhyncha: Cicadellidae: Typhlocybinae) 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

One new leafhopper species, *Dayus* sp. nov. is described from Korea. In this work, description, photographs, and illustrations of the new species are provided. And a key to the Palearctic *Dayus* species is also given.

Key words: Empoascini, leafhopper, *Dayus*, key

P182

Acleris notana (Lepidoptera: Tortricidae: Tortricinae) new to Korea

Hye-Min Byun[1,2] 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

The genus *Acleris* is a large group of the tribe Tortricini. They are occurring from all regions except the Australian. The genus contains 261 species worldwide, and is mainly reported from the Palaearctic region with 147 species. Among them, 45 species are recorded in Korea. In this study, *Acleris notana* (Donovan) is reported for the first time from Korea. Distributions, redescription and illustrations of the specimens including the wing pattern, genitalic structures of male are provided.

Key words: Leaf roller moth, Tortricini

P183

The First Report of the Subfamily Paramacronychiinae with Genus *Goniophyto* Townsend, 1927 (Diptera: Sarcophagidae) from Korea

Jongwon Kim[1,2], Hyeon Lee[1], Dong-June Lee[1], Jae-Seok Lee[1] and Sang Jae Suh[2]
[1]Division of Zoology, Honam National institute of Biological Resources, Mokpo, 58762, South Korea
[2]School of Applied Biosciences, Kyungpook National University, Daegu, 41566, Korea

The family Sarcophagidae commonly known as flesh flies, contains three subfamiles Miltogramminae, Paramacronychiinae, Sarcophaginae with more than 3,000 species worldwide. To date, only two subfamilies Miltogramminae and Sarcophaginae with 43 species are described in Korea. In this study, subfamily Paramacronychiinae is reported for the first time from Korea, with two nominated species: *Goniophyto honshuensis* Rohdendorf, 1962 and *Goniophyto horii* Kurahashi & Suenaga, 1994. The descriptions, photographs to the Korean species are provided herein.

Key words: Taxonomy, Diptera, Sarcophagidae, Paramacronychiinae, *Goniophyto*

P184

A new species of the 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], Seok-Hoon Choi,[1] Bong-Kyu Byun[2] and Yang-Seop Bae[3]
[1]Division of Life Sciences, College of Life Sciences and Bioengineering, Incheon National University, Academi-ro, Incheon, 22012, South Korea
[2]Department of Biological Science and Biotechnology, Hannam University, Daejeon 34054, South Korea
[3]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, 1759. To date, this genus comprises more than 230 species in the world. Among than, 30 species of the genus *Olethreutes* have been reported in the Korean peninsula. The proposes of this study is to describe one new species, with two similar species for Korea.

Key words: Tortricoidea, Palearctic Region, taxonony, n. sp.

P185

Taxonomic notes on the genus *Endotricha* Zeller (Lepidoptera, Pyralidae) in Korea

Hanul Kim[1], Ulziijargal Bayarsaikhan[2], Tak-Gi Lee[1], Yeong-Bin Cha[1], Chang-Moon Jang[1], Jeong-Nam Kim[1], Seok-Hoon Choi[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 genus *Endotricha* was established by Zeller (1847), with type species *Pyralis flammealis* [Denis & Schiffermüller], 1775. *Endotricha* is characterized by the laterally large uncus arms and present of saccular process in the male genitalia. More than 100 described species of this genus have been recorded worldwide (Nuss *et al*., 2003-2022), and eight species have been recorded in Korea (Kim & Paek, 2020). In this study, we reexamined checklist of Korea, based on external characters of the genus *Endotricha.*

Key words: Pyraloidea, Pyralinae, Endotrichini, taxonomy, checklist.

P186

Recent status of the tribe Nomophilini (Spilomelinae, Crambidae) in Korea

Tak-gi Lee[1], Yeong-Bin Cha[1], Hanul Kim[1], Jeong-Nam Kim[1] and Yang Seop Bae[1,2]

[1]Division of Life Sciences, College of Life Sciences and Bioengineering, Incheon National Universtiy, Korea
[2]Bio-Resource and Environmental Center, Incheon National University, Korea

The tribe Nomophilini was established by Kuznetzov & Stekolnikov (1979). Mally et al. (2019) placed two sister clades in Nomophilini, based on 10 genera. Among them, seven species of four genera have been recorded in Korea. In this study, we report the current status of the tribe Nomophilini fauna of Korea, with a newly recorded genus *Syngamia* Guenée, 1854 for one species *Syngamia falsidicalis* (Walker, 1859) from Korea.

Key words: checklist, Lepidoptera, *Syngamia*, newly recorded, illustration

P187

The first complete mitochondrial genome in the family Attevidae (*Atteva aurea*) of the order Lepidoptera

Jun Seong Jeong[1,2], Jeong Sun Park[2], Jae-Cheon Sohn[3], Min Jee Kim[4], Hyung Keun Oh[5] and Iksoo Kim[2*]

[1]Division of Genetic Resources, Honam National Institute of Biological Resources

[2]Department of Applied Biology, College of Agriculture & Life Sciences, Chonnam National University

[3]Department of Science Education, Gongju National University of Education

[4]Experiment and Analysis Division, Honam Regional Office, Animal and Plant Quarantine Agency

[5]Crop Protection Team, Chamfield Co., Ltd, Hanam

The superfamily Yponomeutoidea, one of the early-derived groups in the order Lepidoptera, consists of 11 families. In this study, we present the complete mitogenome of *Atteva aurea* (Fitch, 1856), the first species in the family Attevidae to be sequenced. Within Yponomeutoidea, the mitogenome of *A. aurea* has a unique trnI-trnM-trnQ and trnA-ND3 arrangement. Phylogenetic analyses (ML) based on the concatenated sequences of 13 PCGs and two rRNA genes, revealed a sister relationship between Attevidae and Praydidae with high nodal support (bootstrap support = 80%).

Key words: mitochondrial genome, Yponomeutoidea, arrangement, Phylogenetic analyses

P188

First report of complete mitochondrial genome analysis of blueberry pest, *Dasineura oxycoccana*

Ah Rang Kang[1], Min Jee Kim[2], Jeong Sun Park[3], Byulhana Lee[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

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

2000년대 중반 우리나라에서 재배가 시작된 블루베리는 이후 수요의 급증으로 현재 초기 재배면적의 4배 이상에 달하고 있으며 이로 인해 다양한 해충이 발생하는 것으로 확인되었다. 그 중, 외래해충인 블루베리혹파리는 국내 유입시기와 경로는 불분명하지만, 2010년 국내 블루베리 재배지에서 첫 피해가 보고된 이후 전국적인 분포가 확인되고 있다. 이에 본 연구에서는 추후 지역변이 및 국가별 종 확인 등을 위한 기초정보를 확보하고자 완전 미토콘드리아 유전체 정보를 분석하였다. 블루베리혹파리의 전체 미토콘드리아 유전체는 13개의 PCGs(Protein coding gene), 2개의 rRNA(ribosomal RNA), 22개의 tRNA(transfer RNA), 1개의 A+T-rich region으로 구성되어 있으며 현재 보다 특징적인 구조에 대한 분석이 진행 중이다.

검색어: 외래해충, 블루베리혹파리, 블루베리, 미토콘드리아 유전체

Acknowledgements: This research was supported by the research program of RDA (PJ01509505).

P189

Comparative analysis of two pear pests, *Cacopsylla jukyungi* and *Cacopsylla burckhardti* (Hemiptera: Psyllidae), based on complete mitochondrial genomes and comparison to confamilial species

Ah Rang Kang[1], Min Jee Kim[2], Jeong Sun Park[3], 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

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

Mitochondrial genome(mitogenome) sequences have been used for a diverse field of biology. The two complete mitogenomes of *Cacopsylla jukyungi* (15,438 bp) and *Cacopsylla burckhardti* (14,799 bp) (Hemiptera: Psyllidae) were compared to confamilial species to accumulate genetic information and understand evolutionary characteristics of the family Psyllidae. The complete mitogenomes of *C. jukyungi* and *C. burckhardti* had many features typical of insect mitogenomes; however, at 1,283 bp, the *C. jukyungi* mitogenome had an unusually long A+T-rich region, which was composed of two identical 540-bp repeat sequences. Though the A+T-rich region in available Psyllidae mitogenomes varied substantially in length (662–1,430 bp) and sequence divergence. Our data evidence that the family Psyllidae including current *C. jukyungi* and *C. burckhardti* have evolutionary unique features that were previously undetected, along with the unique A+T-rich region structure in the *C. jukyungi.*

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

Acknowledgements: This research was supported by the research program of RDA (PJ01509505).

P190

Drone pupa (*Apis mellifera*) extract inhibits cell proliferation and induced cell death in HepG2 liver cancer cells

Seonmi Kim, Soon Ok Woo, Se Gun Kim, Hyo Young Kim, Hong Min Choi, Hyo Jung Moon and Sang Mi Han*

Department of Agricultural Biology, National Institute of Agricultural Science, Rural Development Administration, Wanju 55365, Republic of Korea

In 2021, the drone pupa was approved as a new food ingredient based on the record of used for medicinal purpose and scientific data that is nutritionally excellent. According to a recent studies of edible insects, they are paying attention to their potential as nutraceuticals as well as food. To investigate the possibility of antiproliferative effect for malignancy, we observed the viability of HepG2 cells by treating the extract. When the extract was treated in HepG2 cells at 10mg/ml and 5mg/ml for 24 hours, the cell viability were 49.33 and 66.98%, respectively. Detection nucleosomes in cytoplasmic fractions showed that drone pupa extract induced apoptosis in HepG2. Western blotting was used to evaluate apoptosis-related protein expression such as Bcl-2, Bcl-xL, Bax, caspase 3. The result of our study showed that drone pupa extract might provide antiproliferative effect against liver cancer.

Key words: antiproliferative effect, drone pupa(*Apis mellifera* L.).

P191

Molecular and kinetic properties of three acetylcholinesterases in *Varroa destructor*

Sanghyeon Kim[1], Kyungjae Andrew Yoon[1], SuSie Cho[2], Joonhee Lee[2], Youngcheon Lim[2] and Si Hyeock Lee[1,2]

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

[2]Entomology Program, Department of Agricultural Biotechnology, Seoul National University

Although coumaphos, an anticholinesterase pesticide, is widely used for *Varroa* mite, *Varroa destructor*, control, little information is available on the properties of *Varroa* mite acetylcholinesterases (VdAChEs). In this study, three putative VdAChEs were annotated. All VdAChEs possessed most of the functionally important domains, suggesting that they are catalytically active. In phylogenetic analysis, dAChE1 was clustered into a clade containing most arthropod AChE1s, whereas VdAChE2 and VdAChE3 formed a unique clade with other arachnid AChEs. VdAChE1 was determined to be membrane-anchored, but both VdAChE2 and VdAChE3 be soluble. Tissue-specific transcription profiling revealed that VdAChE1 was most predominantly expressed in the synganglion. In contrast, VdAChE2 was predominantly expressed in the legs and cuticle. VdAChE3 showed negligible expression levels in all the tissues examined. VdAChE1 exhibited the highest catalytic efficiency followed by VdAChE2 and VdAChE3. Inhibition experiments revealed that VdAChE1 was most sensitive to all tested inhibitors. Taken together, VdAChE1 appeared to be the major synaptic enzyme, whereas VdAChE2 be involved in other non-catalytic functions including chemical defense against xenobiotics.

Key words: *Varroa destructor*, honey bee, acetylcholinesterase, organophosphate, carbamate, selective toxicity

P192

Tyrosine hydroxylase and DOPA decarboxylase are required for adult cuticle morphology and pigmentation of *Monochamus alternatus*

Mi Young Noh[1], Jiyun Wi[1] and Yasuyuki Arakane[2]
[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 the 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 of *M. alternatus* adults, respectively. These results indicate that both MaTH and MaDDC play critical roles in normal cuticle coloration of *M. alternatus* adult.

P193

Effect of organic watste resource moisture content on larval development of the Black Soldier Fly (*Hermetia illucens*(L.))

Ji-Su Lee[1], Young Uk Park[1], Sun Kook Kim[1], Ju Hee Yu[1], Young Il Kim[1], Ki Su Ahn[1] and Soo Dong Woo[2]
[1]Chungcheongbuk-do Agricultural Research & Extension Services
[2]Dept. Plant Medicine, Chungbuk National University

아메리카동애등에 유충은 음식물폐기물 등 유기성폐자원을 효과적으로 분해할 수 생물로 친환경적 처리방법으로 주목을 받고 있다. 그러나 동애등에를 사육하기 위한 먹이원인 단미사료는 구성 성분과 성상이 다양하며 먹이원의 표준화가 이루어지지 않아 대량사육 시 성장률 차이가 나타나는 문제점이 있었다..이에 본 연구에서는 동애등에 사육을 위한 주요 먹이원인 습식사료와 건식사료의 적정 수분함량을 밝히고자 하였다. 습식사료과 건식사료 500g당 수분함량을 각각 30%, 50%, 70%, 90%로 조성 후 부화한 지 5일 된 동애등에 유충 3,500마리를 투입 후 7일간 발육상태를 조사하였다. 조사 결과 습식사료의 경우 90%는 6.2배, 70%는 9.5배로 먹이활동을 왕성히 한 반면 50%는 –0.4배, 30%는 –0.5배로 발육이 저하되었다. 건식사료의 경우는 90%는 1.8배, 70%는 2.1배, 50%는 0.5배, 30%는 0.07배였다.

검색어: 아메리카동애등에, 유기성폐자원, 먹이원, 수분함량

P194

Antimicrobial activity of apidermin 2 from the honeybee *Apis mellifera*

Bo Yeon Kim[1], Yun Hui 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, Busan 49315, Korea.
[2]Department of Agricultural Biology, National Academy of Agricultural Science, Wanju 55365, Korea.

Apidermins (APDs) are known as structural cuticular proteins in insects, but their additional roles are poorly understood. In this study, we characterized the honeybee, *Apis mellifera*, APD 2 (AmAPD 2), which displays activity suggesting antimicrobial properties. In *A. mellifera* worker bees, the *AmAPD 2* gene is transcribed in the epidermis, hypopharyngeal glands, and fat body, and induced upon microbial ingestion. Particularly in the epidermis of *A. mellifera* worker bees, the *AmAPD 2* gene showed high expression and responded strongly to microbial challenge. Using a recombinant AmAPD 2 peptide, which was produced in baculovirus-infected insect cells, we showed that AmAPD 2 is heat-stable and binds to live bacteria and fungi as well as carbohydrates of microbial cell wall molecules. This binding action ultimately induced structural damage to microbial cell walls, which resulted in microbicidal activity. These findings demonstrate the antimicrobial role of AmAPD 2 in honeybees.

Project No. PJ0157552021

P195

Characterization of Single Crosssd Honey bee (Apis mellifera, AC Lines) in Gyeong-buk Province

Su-Jin Lee[1], Kyung Choi[1], JangBeom Lee[1], Cheonrak Gwon[1], Yong-Soo Choi[2] and Dongwon Kim[2]
[1]Institute of Industrial Entomology, Yecheon County, Korea
[2]Department of Agricultural Biology, National Institute of Agricultural Science, RDA, Wanju 55365, Republic of Korea

우수한 꿀벌 신품종 육성을 위해 국립농업과학원에서 호주이탈리안계통(A)과 황색계통(C)으로 교배조합된 AC계통을 분양받아, 농가에서 사육하고 있는 일반꿀벌을 대조구로 '21년 4월~10월까지 수밀력, 봉군발육, 질병저항성(청소력), 온순성, 프로폴리스 생산량, 플라보노이드 함량을 평가하였다. 일반벌과 AC계통 벌통은 경상북도 예천지역의 양봉사에 고정하여 관행사육하며 조사하였다. 수밀력은 일반벌 16.7mg/마리, AC계통 18.3mg/마리로 AC가 더 무거웠으며, 유밀기 일벌 수는 일벌수는 농가일반벌 약 7,766마리/통, AC계통 약 6,569마리/통으로 조사되어 일반벌과 AC계통의 봉군발육상 유의한 차이는 없었고, 청소능력과 온순성은 AC계통이 우수하였다. 프로폴리스 생산량은 AC계통 64g, 일반벌38.3g으로 AC계통이 59.8% 증수되었고, 플라보노이드 함량은 AC계통이 5.47㎍/g, 일반벌 3.86㎍으로 AC계통이 70.6% 높았다. 결론적으로 프로폴리스 생산량 및 프로폴리스의 기능성 물질인 플라보노이드 함량은 우수하여 프로폴리스 다수확 특성을 지닌 것으로 판단된다.

검색어: 프로폴리스 생산성, 플라보노이드 함량, 수밀력, 봉군발육, 질병저항성, 온순성

P196

Epidemiological monitoring of chigger mite vectors for tsutsugamushi disease in the northwestern region of south Korea, 2018-2020

Jae-chan Lee, Dong-in Kim and Hyung Wook Kwon*
Department of Life Sciences & Convergence Research Center for Insect Vectors, Incheon National University

Scrub typhus, known as tsutsugamushi disease, is a vector-borne disease transmitted by chigger mites. The chigger mites were collected from wild rodents in the Paju area and then assayed by nested PCR for detection of *O. tsutsugamushi*. The captured rodents were 57 Apodemus agrarius and 17 Crocidura spp., and the trapping rate of the rodents was 6.17% (200 traps per day). The mean CI (Chigger mite Index) was 93.06. The CI was highest in April and the CI of the waterway was highest than in other environments. The main species was *L. palidum* (25%), and followed by *N. kwangneungensis* (23.8%). We tested 276 pools of chigger mites to detect *O. tsutsugamushi* and detected 37 positive pools. Main strain was Youngwori strain. In this study, the parasitic chigger mites were found in spring and autumn. However, The incidence of scrub typhus has been occurred in the late fall to winter. Therefore, we need further study to find factors such as seasonal changes in human behavior and the height of the grass. These results provide basic information about the occurrence of chigger mites to devise precautionary measures for tsutsugamushi disease in the Republic of Korea.

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Monitoring of visiting insects according to the planting area of *Dendranthema zawadskii var. lucida* on garden in the Korea National Arboretum

Soo Ho Lee, Sung Won Woo, Ji Yeon Sim, Bo Ra Kim, Ji Young Ryu, Hyun Jin Kim, Hye Young Jin and Young Jae Kim
Gardens and Education Division, Korea National Arboretum

화분매개곤충의 수분은 충매 식물의 생존, 인류의 식량자원 생산 등 많은 역할을 하며 식물과 화분매개곤충의 관련성 연구를 통한 화분매개곤충의 보존은 중요하다. 따라서 본 연구에서는 식물 면적에 따른 화분매개곤충의 개체수 변화를 파악하기 위하여 국립수목원 전시원에 식재된 울릉국화를 대상으로 조사하였다. 조사 방법은 2021년 9~10월에 총 4회 실시하였고, 면적은 1x1m, 2x2m, 4x4m로 하였다. 울릉국화가 70% 이상 개화했을 때 포충망을 이용하여 곤충을 채집하였다. 조사 결과 울릉국화의 식재 면적이 넓어짐에 따라 방문 곤충의 종은 증가하지 않았고 개체수는 증가하였다. 6종의 우점종 중에서 점박이꽃검정파리, 호리꽃등에, 배짧은꽃등에 3종은 울릉국화의 식재 면적이 넓어짐에 따라 개체수가 점차 증가하였다. 꽃등에는 1x1m 3개체, 2x2m 23개체, 4x4m 21개체로 2x2m와 4x4m가 비슷하지만 2x2m에서 더 많았다. 꼬마꽃등에와 애긴노린재는 1x1m와 2x2m에서 개체수가 비슷하다가 4x4m에서 증가하며 일정한 경향을 보이지 않았다. 식재 면적은 방문 곤충의 개체수에 영향을 미치는 것으로 판단되며 다양한 화분매개곤충을 유도할 수 있는 추가적인 연구가 필요하다.

검색어: 울릉국화, 식재 면적, 화분매개곤충

P198

Hibernation experiment of larvae of *Callipogon relictus* Semenov

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

The Korea National Arboretum has established a habitat-customized breeding system for the conservation and breeding of *Callipogon relictus*. Under this system, we conducted hibernation experiments on the *C. relictus* larvae in order to understand the ecological characteristics as well as breeding at the appropriate temperature and humidity. The experiment was carried out only with the last instar larvae. As a result of the experiment, the survival rate, emergence rate, and malformation rate of the larvae were recoroded. In addition, by measuring the head capsule width and weight of the last instar larvae, the correlation between the body length and weight of the adult was also confirmed.

Key words: *Callipogon relictus*, conservation, ecology, hibernation

P199

Confirmation and comparison of flight and dispersal ability of the *Callipogon relictus* Semenov using flight mill and radio telemetry

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

Callipogon relictus 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 and radio telemetry tracking experiment to understand ecological characteristics such as the ability to flight and dispersal of *C. relictus* inhabiting in Gwangneung forest. The experiments were compared the results of flight mill experiment in laboratory and a tracking experiment using a radio tag in Gwangneung forest. Also, as a result of the experiments, it were confirmed whether there were differences in flight and dispersal abilities according to biological characters such as the sex, body length, elytra length, elytra width, weight and etc.

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

P200

Corn leaf feeding amount by the development stages of *Spodoptera frugiperda* according to temperature

Seongkyun Lee, Young-Uk Park, Jongok Jeon and Juhyung Kim
Chungbuk Agricultural Research and Extension Services, Cheongju

Spodoptera frugiperda Smith (Lepidoptera: Noctuidae) is a lepidopteran pest that infests more than 80 crops, including corn, rice, sorghum, sugarcane, cotton, and other vegetable crops. The larvae of *S. frugiperda*, in particular, have caused severe damage to monoculture crops such as corn, sorghum, cotton, and soybean. The highest amount of feeding (6.6 g) was observed at 16℃ at 6.6 g and the lowest (0.9 g) was observed at 36℃. According to the feeding amounts, the damage seems to be most severe at 16℃, which is natural because the growth period is the longest at 16℃ as the growth is reduced owing to low temperature. The daily corn leaf feeding amount of *S. frugiperda* was compared to determine the temperature at which feeding is most active.

Key words: *Spodoptera frugiperda*, corn feeding amount, damage

P201

Occurrence patterns of major moth by region in soybeans (2022)

Hwi Jong Yi, Rameswor Maharjan, Seo yeon Hong, YoungNam Yoon and YunWoo Jang
Department of Southern Area Crop Science, National Institute of Crop Science, RDA

파밤나방과, 담배거세미나방은 기주범위가 넓은 잡식성 나방류 해충으로, 콩의 주요 해충이다. 비래 해충으로 알려져 있지만 시설재배가 늘어나면서 국내에서 월동 가능성 높은 해충이기도 하다. 콩에는 연2~3회 발생하며 지역별로 발생양상에 차이를 보인다. 콩은 주요 식량작물로 기후를 고려해 중부, 영남, 호남지역에서 품종육성이 이루어 지고 있다. 이에 각각의 지역에서 두 나방의 발생양상을 조사하였다.

파밤나방의 경우 중부(수원), 영남(밀양), 호남(부안) 지역에서 4월부터 성충이 발생해 밀도가 서서히 증가하다가 7월중순 1차 최대성기를 나타냈다. 담배거세미나방의 경우 5월부터 성충이 발생하기 시작해 6월하순에서 7월상순 1차 최대성기를 보였다. 파밤나방과 비교했을 때 약 10일 정도 빨랐다. 콩은 이 시기 생육 초·중기로 섭식에 의한 엽 피해가 클 경우 생육이 지연되고, 수량에 영향을 준다. 따라서 7월상순에서 중순에는 유충의 발생정도를 주의깊게 관찰해 적기에 방제토록 해야 한다.

검색어: 파밤나방, 담배거세미나방, 발생양상

P202

Occurrence of thrips and chemical control on red pepper in Yeongyang, Gyeongbuk Provice

Oh Hun Kwon[1,2], Chan Yong Kim[2] and Mun Jung Lee[1]
[1]Organic Agriculture Research Institute, Gyeongbuk ARES, Uiseong
[2]Yeongyang Pepper Research Institute, Gyeongbuk ARES, Yeongyang

경북 영양지역 노지고추 재배지에서 2019년부터 2021년까지 총채벌레의 발생양상을 조사하고 피해를 줄이기 위한 방제시기를 설정하기 위해 수행하였다. 발생조사는 영양지역 임의 10개 포장을 선정하여 5월부터 9월까지 실시하였다. 총채벌레의 발생소장은 6월 하순~7월 상순, 7월 하순~8월 상순, 8월 하순에 걸쳐 총 3회의 발생최성기를 보였고, 대만총채벌레가 93.1%로 우점하였다. 총채벌레에 의한 피해과율은 연도에 따라 6.7~9.8%로 나타났다. 또한, 총채벌레 발생소장 조사결과를 토대로 약제방제 시험을 수행한 결과, 6월 중순 1회, 7월 상순부터 10일 간격 3회 약제살포가 효과적인 것으로 나타났다.

검색어: 고추, 총채벌레, 발생양상, 방제

P203

Preliminary study of parasitic rate of *Anastatus orientalis* (Hymenoptera: Eupelmidae) on eggmass of spotted lanternfly for spring-to-summer collection

Yeongmo Kim[1], Yeonghyeok Yu[1], Duk-Young Park[2], Seunghwan Lee[2,3] and Hyojoong Kim[1]
[1]Animal Systematics Lab., Department of Biological Science, Kunsan National University, Gunsan, 54150, Republic of Korea
[2]Insect Biosystematics Laboratory, Department of Agricultural Biotechnology, Seoul National University, Seoul 08826, Republic of Korea
[3]Research Institute of Agriculture and Life Sciences, Seoul National University, Seoul 151-921, Republic of Korea

To find out how *Lycorma delicatula* (spotted lanternfly; SLF) population is parasitized by *A. orientalis* as a bio-control agency, we investigated the parasitic rate of *A. orientalis* on SLF eggmass. In addition, the emergence patterns of *A. orientalis* were determined to investigate the eggmass in spring-to-summer collection. SLF eggmasses were collected in Buyeo per a month from March to June. In laboratory, each collected eggmass was placed in a cage and recorded emergence of both parasitoid and SLF nymph per a week. *A. orientalis* emerged mid-April to late-May. In SLF, there were few emerges from mid-April to early-May, when *A. orientalis* emerged most, and more emerges in mid-May. However, from May, we found many eggs were already hatched or emerged, and there was no emergence in the lab in June. In July and August, newly laid eggmasses were neither found or collected.

Key words: biological control, egg parasitoid, life-table, natural enemy

P204

Surveilance of sporadic and subtropical insect pests in Gyeongnam province

Seok Min Lee*, Young Don Chin, Dong Wan Kang, In Young Han and Jae Hyeok Choi
Environmental Agriculture Research Division, Gyeongsangnam-do Agricultural Research & Extension Services, Korea

기후변화와 세계시장 개방에 따른 외래 및 돌발해충의 종류는 다양해지고 밀도는 지속적으로 증가하고 있지만 발생 실태에 관한 자료는 미흡하다. 본 연구는 경남지역 돌발 및 남방계 해충의 발생과 피해조사를 위해 미국선녀벌레, 썩덩나무노린재, 담배거세미나방 등 3종을 경남 18시·군에서 조사하였다. 미국선녀벌레는 약충기(6월), 성충기(9월) 조사를 진행하였고, 길이가 50cm 이상되는 가지의 밑동에서 위쪽으로 50cm 내 개체를 육안조사하였다. 썩덩나무노린재는 콩 개화기(7월), 등숙기(9월) 조사를 진행하였고 지점당 집합페로몬 트랩 1개를 설치하고 1주 후 채집된 마리 수를 조사하였다. 담배거세미나방은 성페로몬 트랩 1개를 설치한 뒤 1주 후 채집된 마리 수를 조사하였다. 미국선녀벌레는 산청 고성, 함안, 의령 등에서 발생이 많았고, 전년대비 발생이 소폭 증가하였다. 썩덩나무노린재는 남해에서 가장 발생이 많았고, 합천, 거제, 밀양, 창녕, 의령 순으로 발생하였다. 담배거세미나방은 전시군에서 발생이 확인되었으며, 특히 의령, 거제, 밀양, 진주 등에서 밀도가 높았다.

검색어: 경남지역, 돌발해충, 남방계해충, 발생조사

P205

Occurrences of insect pests in *Rubus crataegifolius* in Gyeongnam Province

Seok Min Lee*, Young Don Chin, Dong Wan Kang, In Young Han and Jae Hyeok Choi
Environmental Agriculture Research Division, Gyeongsangnam-do Agricultural Research & Extension Services, Korea

Rubus crataegifolius is a shrub species and primarily distributed throughout Asia and Europe. As cultivation area of *Rubus crataegifolius* increases, the damage caused by insect pest is also increasing. But, development of pest control technologies is insufficient.

This study was conducted to investigate the occurrence and damage of insect pests in *Rubus crataegifolius* in Gyeongnam province and utilize it as basic data for development of major pest control technology. As a result, 11 species of insect pests were investicated. In particular, *Aceria kuko* occurred throughout the growing season. Damaged leaves are reduced in growth and the amount of photosynthesis is greatly reduced. *Frankliniella occidentalis* mainly lives in flowers during the flowering period, and even the harvest, giving consumers a sense of disgust. *Drosophila suzukii* occur in late harvested fields, and larvae emerge from the harvest, giving consumers a sense of disgust.

Key words: *Rubus crataegifolius, Aceria kuko*, *Frankliniella occidentalis, Drosophila suzukii*

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Occurrences of insect pests in *Mangifera indica* in Gyeongnam Province

Seok Min Lee*, Young Don Chin, Dong Wan Kang, In Young Han and Jae Hyeok Choi
Environmental Agriculture Research Division, Gyeongsangnam-do Agricultural Research & Extension Services, Korea

최근 기후변화에 따라 아열대 작물 재배가 증가하면서 경남지역 망고 재배면적도 크게 증가하고 있다. 하지만 망고에 발생하는 병해충 발생 정보가 부족해 방제에 어려움을 겪고 있으며, 병해충 방제를 위한 기초자료를 제공하고자 본 연구를 수행하였다.

2022년 1월부터 9월 상순까지 통영, 김해, 밀양, 함안 등에서 망고에 발생하는 병해충 발생조사를 수행하였다. 경남지역 망고재배지에서 발생하는 병해는 잿빛곰팡이병, 탄저병, 가지마름병, 그을음병, 줄기마름병 등 5종이 확인되었고, 해충은 목화진딧물, 꽃노랑총채벌레, 담배가루이, 점박이응애, 담배거세미나방, 깍지벌레류 6종이 확인되었다. 특히 꽃노랑총채벌레의 경우 가온을 하는 망고 포장 특성상 연중 발생하여 농가에 피해를 주고 있고, 꽃노랑총채벌레가 흡즙한 과실은 과피 변형이 일어나 상품성이 저하되었다.

Key words: *Mangifera indica, Frankliniella occidentalis, Aphis gossypii*

P207

Current Status of Candidate list of Alert Alien Insect Species in South Korea

Aram Jo, Heejo Lee and Dong Eon Kim
Invasive Alien Species Team, National Institute of Ecology, Seocheon, Korea

「생물다양성 보전 및 이용에 관한 법률」에 따라 환경부는 국내에 유입될 경우 생태계에 위해를 미칠 우려가 있는 외래생물을 유입주의 생물(398종)로 지정·고시하여 관리하고 있다. 하지만 식물방역법상 살아있는 병해충은 수입이 금지되어 있어 곤충류는 유입주의 생물에서 제외되었다. 그러나 침입외래종에 대한 사전 관리 강화 및 법정관리종 지정 확대를 위해 2014년부터 2022년까지 곤충류에 대한 유입주의 생물 후보를 목록화하여 총 655종을 발굴하였다. 바구미과(Curculionidae)가 90종(14%)으로 가장 높은 비율을 차지하였고, 그 다음으로 과실파리과(Tephritidae) 63종(10%), 하늘소과(Cerambycidae) 50종(8%), 잎벌레과(Chrysomelidae) 37종(5%), 잎말이나방과(Tortricidae) 31종(4%) 등의 순이었다. 이 결과로 발굴된 곤충류에 대해 전문가 검토를 거쳐 유입주의 생물로 지정·고시하고 국내 유입을 사전에 차단하여 생물다양성 보전에 기여할 것으로 기대된다.

검색어: 유입주의 생물, 외래생물, 생태계위해성평가, 법정관리종

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Effects of antiparasitic drugs(Ivermectin) via food chain on dung beetle *Onthophagus lenzii*

Jongdae Park[1,2], Young-Joong Kim[1], Hwang Kim[1], Deokjea Cha[1], Mannyun Kim[1,2] and Jong Eun Lee[2]
[1]Division of Restoration Research, National Institute of Ecology, Yeongyang, Republic of Korea
[2]Department of Biological Science, Andong National University, Andong, Republic of Korea

가축에 투여하는 구충제는 가축 배설물을 먹이로 하는 곤충에게 노출 될 수 있으며, 이러한 약물의 사용은 그들의 개체군에 부정적인 영향을 미칠 수 있다. 본 연구는 국내에서 사용되는 대표적 동물용 구충제인 Ivermectin을 이용하여 렌지소똥풍뎅이(*Onthophagus lenzii*)를 대상으로 가축 배설물에 잔류하는 구충제의 잠재적 위해성을 조사하였다. 분변을 통해 노출되는 Ivermectin은 투약 후 1일차에 가장 높은 농도를 보였고 16일 차 이후 더 이상 검출되지 않았다. 또한 Ivermectin이 포함된 분변과 그렇지 않은 분변을 섭취한 렌지소똥풍뎅이의 생활사적 특성을 비교한 결과, 생존에 유의미한 차이가 있는 것을 확인 할 수 있었다. 이를 통해 분식성 곤충에 대한 위해성을 최소화 할 수 있는 구충제의 적정 투약시기를 제시할 수 있을 것으로 기대한다.

검색어: Ivermectin, 구충제, 렌지소똥풍뎅이, 분식성 곤충, 생태 위해성

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Occurrence Pattern of Insect Pest in Citrus Orchards in Jeju, Korea

Jeong Hoon Park, Hyo Jeong Kim , Ho Jun Kang and Jeong Heub Song
Division of sustainable agriculture research, Jeju Agricultural Research & Extension Services

기후변화에 따라 변화하는 해충 발생 양상을 평가하기 위해 2020년부터 2021년까지 도내 감귤원을 대상으로 발생 해충 종류 및 피해를 조사하였다. 감귤에 발생하는 해충으로 총 7목 30과 55종이 조사되었으며, 본 조사에서 산둥날개매미충, 식나무가루이 발생이 새롭게 확인되었다. 일반재배 감귤원에서 주요 피해 해충은 귤응애, 조팝나무진딧물, 귤굴나방이었으며, 과거에 비해 호랑나비의 발생과 피해가 증가하였다. 유기재배 감귤원에서는 진딧물류, 깍지벌레류, 귤굴나방 등에 의한 피해가 심했으며, 일부 과수원에서는 알락하늘소 피해가 심한 경우도 있었다.

검색어: 감귤, 해충종류, 주요해충, 피해

P210

Occurrence of *Ricania shantungensis* (Hemiptera: Ricaniidae), a New Insect Pest in Citrus Orchards in Jeju, Korea

Jeong Hoon Park, Hyo Jeong Kim, Ho Jun Kang and Jeong Heub Song
Division of sustainable agriculture research, Jeju Agricultural Research & Extension Services

제주지역 감귤원에서 산둥날개매미충(*Ricania shantungensis*)의 피해가 새롭게 확인되어 2019~2020년에 걸쳐 그 발생생태 및 분포상황을 조사하였다. 제주지역에서 산둥날개매미충은 3월까지 휴면 알 형태로 월동하며, 월동세대는 4월~9월, 1세대는 8월~12월까지 연 2회 발생하고 있었다. 감귤에서는 신초를 흡즙하거나 8월부터 10월까지 봄과 여름에 발생한 가지에 산란하여 피해를 주었다. 제주지역에서 산란 및 흡즙 기주식물은 아왜나무 등 16종이 확인되었다. 산둥날개매미충의 도내 분포지역을 황색끈끈이트랩을 이용하여 조사한 결과 제주시 한림읍과 한경면 지역에 분포하고 있었다.

검색어: 산둥날개매미충, 감귤, 해충, 분포

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Host-biased aggregation of *Ramulus mikado* on *Robinia pseudoacacia*, but why?

Seul-Ki Son[1], Yong-In Kim[2], Junghoon Lee[2], Min Jeong Baek[3], Sun-Jae Park[3] and Jong-Kook Jung[1*]
[1]Department of Forest Environment Protection, Kangwon National University, Chuncheon 24341, Korea
[2]Department of Life Science, Hallym University, Chuncheon 24252, Korea
[3]National Institute of Biological Resources, Incheon 22689, Korea

Since 2020, *Ramulus mikado* (Insecta: Phasmatodea) was one of tremendous defoliators in central Korea, but knowledges in relationship between *R. mikado* and environmental conditions were lacking. From April to July in 2022, we investigated number of individuals of *R. mikado* in three main host tree species, such as *Prunus serrulata* var. *pubescens*, *Quercus mongolica*, and *Robinia pseudoacacia*, in Cheonggy mountain, and we also analysed carbon:nitrogen ratio of those tree species. As a result, cumulative number of individuals of *R. mikado* was significantly higher in *R. pseudoacacia* compared to others, while C/N ratio of *R. pseudoacacia* was significantly lower than others, which indicated that *R. pseudoacacia* was nitrogen-rich species. Therefore, *R. pseudoacacia* may be an important host plant species in rapid completion of *R. mikado* development.

Key words: Stick insect; Outbreak: Population density; Host plant; C/N ratio

※ This work was supported by a grant from the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR202211101).

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Surveilance of Sporadic Insect Pests in Jeonbuk Province

Su Ji Jang, Hyung Cheol Moon, Min Kyung Choi, Hyung Guk Kim and Min Sil Ahn
Agricultural Environment Division, Jeonbuk Agricultural Research and Extenstion Services

The Surveilance of sporadic insect pest in Jeonbuk province was confirmed. In June and July 2022, the incidence of *Halyomorpha halys*, *Metcalfa pruinosa*, and *Spodoptera litura* was investigated in the persimmon tree and soybean cultivation packaging in 14 counties in Jeonbuk province. The *Metcalfa pruinosa* was visually inspected, and the *Metcalfa pruinosa* and *Spodoptera litura* were counted 7 days once after the installation of the pheromone trap. The nymph of the *Metcalfa pruinosa* occurred in 7 conties. The *Halyomorpha halys* was most common in the plains such as Gunsan and Iksan. *Spodoptera litura* was most common in Gimje and Buan.

Key words: Sporadic insect pest, *Metcalfa pruinosa, Halyomorpha halys, Spodoptera litura*

P213

Insect fauna in the Honam region upland crop fields

Seon-U Choi, Sang-Young Seo, Hyo-Jung Choi and Min-Sil Ahn
Jeollabuk-do Agricultural Research and Extension Services

As part of Assessment of biological variation in agricultural land, we report the results of the survey on insect fauna in eco-friendly and conventional upland fields in Honam area. The occurrence survey of arthropod was conducted using traps and sweeping for five crops, including cabbage, red pepper, beans, ginger, and taro. We identified 23,235 individuals of 25 orders, 149 families and 362 species. We collected a total of 13,303 individuals from conventional fields and a total of 9,932 individuals from eco-friendly fields. Excluding the Collembola, we collected a 3,312 individuals from conventional fields and a total of 8,501 individuals from eco-friendly fields. In collecting from eco-friendly fields, the four representative orders are the Hemiptera(2,958 individuals), Hymenoptera(1,993), Diptera(1,591), Thysanoptera(1,092). In insects collected from conventional fields, the four representative orders are the Collembola(9,968 individuals), Hymenoptera(995), Hemiptera(889), Diptera(629).

Key words: upland crop field, eco-friendly fields, conventional fields, insect fauna

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Hemistepta lyrata use as *Harmonia axyridis* banker plant in agricultural ecosystem

Seon-U Choi, Sang-Young Seo, Hyo-Jung Choi and Min-Sil Ahn
Jeollabuk-do Agricultural Research and Extension Services

Most of the natural enemies that can be purchased to control agricultural pest aphids are parasitic wasps. If farmers fails aphid control using the purchased natural enemy parasitic wasps, they want to increase the control effect by ladybugs release. Currently, ladybugs are difficult to purchase in Korea. They go out to the field to capture them. Therefore, this experiment was conducted to provide information on plants in which ladybugs are attracted in spring. From March to June, *Hemistepta lyrata*. is one of the plants in which ladybugs were captured in agricultural land. Ladybugs were able to capture up to 18 per square meter in the native habitat of *Hemistepta lyrata*. Ladybugs are attracted by aphids *Uroleucon* spp. that occur in *Hemistepta lyrata*. Some farmers think that all aphids generated from plants in the agricultural ecosystem damage crops. They are removed when aphids are generated in *Hemistepta lyrata*. Therefore, we need research and promotion to change the perception of farmers.

Key words: ecosystem, banker plant, ladybug, aphid, *Hemistepta lyrata*

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Diversity of ground dwelling carabid beetle community by altitude of Mt. Yuhaksan, Chilgok-gun (Coleoptera: Carabidae)

Sung Ho Kim[1,3], Jong Bong Choi, Eun Young Choi[2], Taeyeong Kwon[2], Myeonghwan Kim[2], Myeong Cheol Kim[2], Hee Soo Lee[2] and Jong Kyun Park[2]
[1]Graduate School of Plant Protection and Quarantine, Kyungpook National University
[2]Department of Ecological Science, Kyungpook National University
[3]Chilgok Agricultural Technology Center, Chilgok-gun

경상북도 칠곡군 석적읍과 가산면 경계에 위치한 유학산(해발 839m)의 북사면에서 해발고도 400m~800m까지 총 6지점을 설정하여 지표보행성 딱정벌레과 군집의 다양성을 조사하였다. 그 결과 전체 지점 및 조사 기간 동안 총 16종 1,123개체가 채집되었고, 붉은칠납작먼지벌레가 879개체로 가장 많았으며, 팔공우리딱정벌레 100개체, 진홍단딱정벌레 97개체, 윤납작먼지벌레 22개체, 멋쟁이딱정벌레 6개체, 기타 먼지벌레류 19개체 순으로 채집되었다. 고도별 종수는 '700m'이 9종 167개체로 가장 높게 나타났고 다음으로 '자작나무갱신지' 9종 124개체, '800m' 7종 130개체, '400m' 7종 67개체, '500m' 6종 194개체, '600m' 5종 441개체, 월별 종수는 7월 10종 306개체로 가장 높게 나타났고 다음으로 6월 9종 671개체, 5월 9종 146개체로 나타났다. 전체 조사 기간 동안 모든 지점에서 우점종은 붉은칠납작먼지벌레, 아우점종은 '400m', '500m', '자작나무갱신지'에서 진홍단딱정벌레가, '600m', '700m', '800m'에서 팔공우리딱정벌레로 조사되었으며, 모든 지점에서 우점도가 다소 높으나 특히 '400m'~'600m'에서 매우 높게 나타났다. 지점별 다양도, 균등도 및 종풍부도는 우점도가 가장 높은 '600m'지점에 가장 낮았으나, 다양도가 가장 높은 곳은 '자작나무갱신지'와 '800m', 균등도가 가장 높은 곳은 '800m', 종풍부도가 가장 높은 곳은 '자작나무갱신지'로 출현종수에 따라 각각 다르게 나타났다.

검색어: 딱정벌레과, 다양성, 군집분석

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Arthropods' discovered in Incheon port containers

Dayeong Kim, Dong Eon Kim, Nang-Hee Kim, Min-Ji Lee, Young-Gyu Ban, Beom-jun Jang and Heejo Lee*
Invasive Alien Species Team, National Institute of Ecology, Seocheon, Korea

세계화로 인해 활발해진 교역, 수송 등으로 외래종의 유입과 확산이 증가하고 있는 실정이다. 선박을 통해 수출입되는 화물량의 증가로 국내 항만에서 발견되는 붉은불개미(*Solenopsis invicta*), 긴다리비틀개미(*Anoplolepis gracilipes*) 등 위해 외래곤충이 증가하고 있다. 위해 외래생물의 유입을 막고 확산 방지를 위한 선제적 대응으로 인천항으로 반입되는 수입 공컨테이너 실태조사를 실시하였다. 2020년 하반기부터 2022년 상반기까지 총 4차례 조사한 결과 거미류 24종, 곤충류 21종, 지네류 1종이 확인되었다.

검색어: Arthropods, Invasive alien species, Empty containers

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Host preference and development of *Spodoptera frugiperda* (Smith) on different crops (Lepidoptera: Noctuidae)

Hyung Cheol Moon, Su Ji Jang, Min Kyung Choi, Jang Ho Lee, Hyung Guk Kim and Min Sil Ahn
Agricultural Environment Division, Jeonbuk Agricultural Research and Extension Services

The fall armyworm, *Spodoptera frugiperda*, is a polyphagous invasive migratory pest native to the tropics that has recently invaded Korea with subsequent damage to cornfield. Up to now, no crops damaged by this species have been identified in addition to corn, sorghum, sudangrass and ginger in Korea. The host preference and development characteristics of the five crops such as peanut, soybean, tomato, red pepper and watermelon have been investigated to confirm the possibility of the crops with a large cultivation area among the crops in Jeonbuk area. The host preference of *S. frugiperda* was highest on soybean, followed on peanut and low on watermelon and tomato. The larval and pupal development periods was 23.7 days/11.3 days, 23.3 days/11.3 days, 36.2 days/12.8 days, 34.0 days/12.2 days and 31.5 days/12.7 days in peanut, soybean, tomato, red pepper and watermelon, respectively, which was longer than 19.8 days/10.8 days in corn.

Key words: *Spodoptera frugiperda*, host preference, development

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Predation and life table of *Feltiella acarisuga* (Diptera: Cecidomyiidae) preying on eggs of *Tetranychus urticae* (Acari: Tetranychidae)

Yong-Seok Choi, Yoon-Sung Won, Gun-Woo Lee, In-Soo Hwang, In-Soo Hwang and Gyeong-Ju Lee
Chungnam Agricultural Research & Extension Services, Yesan 32418, Korea

Feltiella acarisuga (Vallot) is a common gall midge that feeds on many species of spider mites. Predation and all major biological and life table of *F. acarisuga* were determined using eggs of the twospotted spider mite, *Tetranychus urticae* (Koch), as prey under laboratory condition (27.9±0.5°C, 90% RH, and 14:10 [L:D] h). First-, second-, and third-instar *F. acarisuga* larvae conseumed an average of 41.6, 63.6, and 91.9 *T. urticae* eggs, respectively. Larvae consumed a total of 193.7 eggs each from first to third instars, and female larvae consumed 206.1 spider mite eggs, 13.7% more than male larvae. Developmental time of F. acarisuga was 1.7, 5.8, and 4.3 d for eggs, larvae, and pupae, respectively, with an average of 20.4 d from oviposition to adult emergence. Female immatures developed slightly slower (1 d) than males.

Key words: Cucumber, *Orius laevigatus*, *Ocimum basilicum*, Banker plant, Biological control

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Species identification of stink bugs and ear damage in sweet corn fields, Suwon

Eun Young Kim, I Hyeon Kim and Jin Kyo Jung
Crop Cultivation and Environment Division, Natl. Institute of Crop Science, RDA

최근 국내 단옥수수 및 초당옥수수 재배지가 증가하여 2021년 현재 680 ha가 재배되고 있다. 2022년 7월 초 수원의 옥수수포장에서 재배 중인 8 품종/계통의 옥수수 (메가골드, 고당옥 등)에서 노린재류가 발견되었다. 채집한 노린재는 알락수염노린재(*Dolycoris baccarum*), 풀색노린재(*Nezara antennata*), 시골가시허리노린재(*Cletus punctiger*), 홍색얼룩장님노린재(*Stenotus rubrovittatus*) 4종으로, 미토콘드리아 사이토크롬 c산화효소 I(COXI) 염기서열 분석을 통해 종을 확인하였다. 야외에서 채집한 풀색노린재(성충 23마리, 약충 10마리), 알락수염노린재(성충 6마리)를 실험실에서 수확기 초당옥수수 이삭 알갱이를 1일간 제공하였을 때, 알갱이 피해율은 약 65%, 27%로 이삭을 가해할 수 있는 것이 확인되었다. 같은 시기 옥수수 포장 내 초당옥수수(반딧불이초당 품종) 출사일 2일 후 이삭에 망을 씌워 알락수염노린재와 풀색노린재를 각각 마리수별(1, 5, 10마리)로 접종하고, 15일 후 살아있는 노린재와 이삭 가해 흔적을 확인하였다.

Key words: 초당옥수수, 노린재, 종동정, 이삭피해

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Patterns of insect pests occurrences on *Allium microdictyon* in Gangwon Province

Youn Gi Moon[1], Se Won Kim[1], Hyo Young Lee[1], Nam Gil Lee[1], Ki Duk Park[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

9년간(2014~2022년) 강원도 지역(평창군, 횡성군, 홍천군 등)의 산마늘 포장에서 산마늘의 꽃, 꽃대, 잎, 줄기, 뿌리를 가해하여 피해를 주는 해충류를 조사하였다. 나비목 2종(도둑나방, 파좀나방), 딱정벌레목 3종(참검정풍뎅이, 청동방아벌레, 파잎벌레), 파리목 1종(작은뿌리파리), 총채벌레목 1종, 전기문목 1종(클로버응애) 등 총 5목 8과 8종의 해충을 확인하였다. 이 가운데 경제적으로 큰 피해를 주는 종류는 참검정풍뎅이, 파잎벌레, 파좀나방, 클로버응애 등 4종 이었다. 파잎벌레는 횡성지역에서 4~5월에 발생하여 잎, 꽃, 꽃대를 남김없이 모두 가해하였고, 참검정풍뎅이는 평창지역에서 4~5월에 발생하여 뿌리를 가해하여 지상부 잎을 노랗게 변하게 하였다. 파좀나방은 꽃봉오리를 가해하여 종자 결실에 큰 피해를 주었다. 클로버응애는 홍전지역에서 4~5월에 발생하여 잎을 가해하여 상품성이 크게 하락하였다. 모두 개별 사육을 통해 성충 발생을 확인 후, 종 동정하였고, 산마늘에 피해를 주는 발생시기와 가해부위 그리고 피해정도 등을 조사하여 관련 정보를 확보하였다.

검색어: 산마늘, 참검정풍뎅이, 파잎벌레, 파좀나방, 클로버응애

P221

Seasonal occurrence of endangered grasshopper *Haplotropis brunneriana* Saussure, 1888 in Korea

Mannyun Kim[1,2], Young-Joong Kim[1], Jong Dae Park[1,2] , Changmann Yoon[1] and Jong Eun Lee[2]

[1]Division of Restoration Research, National Institute of Ecology, Yeongyang, Republic of Korea
[2]Department of Biological Science, Andong National University, Andong, Republic of Korea

뚱보주름메뚜기(*Haplotropis brunneriana*)는 서식지가 줄어들고 개체군이 감소하여, 환경부 지정 멸종위기 야생생물 II급으로 법적 보호를 받고 있다. 하지만 멸종위기종인 뚱보주름메뚜기에 대한 개체군 크기 변화, 분포 현황, 서식지 특성 등 연구자료는 부족한 상황이다. 따라서 본 연구는 뚱보주름메뚜기의 개체군 발생 현황을 조사하여, 멸종위기종 복원에 필요한 기초자료로 활용하고자 수행하였다. 연구는 강원도 영월, 충청북도 제천, 경상북도 의성 등 3개 지역에서 선조사법(Line transect)을 이용해 각각 880㎡, 960㎡, 320㎡ 크기의 조사지를 3월부터 6월까지 월 3회 조사하였다. 조사 결과 야생에서 뚱보주름메뚜기는 3월 초순부터 활동하기 시작했으며, 6월에는 개체가 거의 나타나지 않았다. 또한 3개 지역 모두 5, 6월보다 3, 4월에 많은 개체가 확인되었다. 확인된 총 개체수는 영월 51개체, 제천 27개체, 의성 28개체였으며, 개체군 밀도는 조사지 중 제천 지역이 면적에 비해 적은 수의 개체가 확인되어 낮게 나타났다.

검색어: 뚱보주름메뚜기, 개체군 밀도, 멸종위기 야생생물, 선조사법

P222

Surveilance of sporadic insect pests in Gyeonggi Province

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

기후 변화에 따라 외국에서 유입된 매미충류의 국내 토착화가 진행되고 있으며, 이로 인한 농경지 피해가 증가하고 있는 추세이나 이에 대한 실태 조사는 부족한 실정이다. 따라서 본 조사에서는 경기지역에 발생하는 돌발해충 매미충류 2종(미국선녀벌레, 갈색날개매미충)에 대해 월동기(2월), 약충기(6월), 성충기(9월) 밀도 조사를 수행하였다. 조사지역은 경기도 주요 농경지역 17개 시.군을 대상으로 하였으며 기주 식물인 감나무를 정점조사하였다. 갈색날개매미충은 약충기 화성, 성충기 평택, 미국선녀벌레는 약충기 가평, 성충기 광주지역에서 높은 밀도로 확인되었다. 특히 미국선녀벌레 조사결과 약.성충기 모두 고속도로 주위 지역이 타지역에 비해 밀도가 높아 추후 공동방제시 활용할 경우 효과를 극대화할 수 있을 것이라 기대한다.

검색어: 돌발해충, 기후변화, 분포조사, 경기지역

P223

Analysis of Relationship between Land Cover Types and Appearance of Terrestrial Insects in the Civilian Control Zone (CCZ) of South Korea

Jinyoung Park and Hyun Su Hwang
National Institute of Ecology, Republic of Korea

The region north of the Civilian Control Zone (CCZ) of South Korea is about 8km long and 1,133㎢ in area from the Southern Limit Line (SLL) to the Civilian Control Line (CCL), accounting for 1.13% of the national territory. And it accounts for 16.1% of all species identified in Korea. The CCZ is an area where authorized civilians and restricted agricultural activities are allowed, and unauthorized civilians are restricted from access. The CCZ serves as a buffer zone for wildlife inhabiting the Demilitarized Zone (DMZ), and is a very important habitat for large mammals and endangered wildlife.

This study divided the CCZ into five survey areas from 2015 to 2020 and analyzed the relationship between land cover types and appearance of terrestrial insects.

Key words: Civilian Control Zone (CCZ), Demilitarized Zone (DMZ), land cover, terrestrial insects, South Korea

P224

Distribution and insecticideal effect of the spotted-wing drosophila, Drosophila suzukii, in Korean cherry orchards

Sun-Young Lee[1] Jung Beom Yoon[1], Mi Hye Seo[1], Seong Chan Lee[1] and Chang Yeol Yang[2]
[1]Horticultural and Herbal Crop Environment Division, National Institute of Horticultural & Herbal Science, RDA,
[2]Technology Cooperation Bureau, Rural Development Administration

벗초파리는 핵과류와 베리류에 큰 피해를 주는 해충으로 알려져 있으며 아시아 원산으로 현재 북미와 유럽에도 침입하여 피해를 주고 있다. 과거 우리나라에서는 농작물에 대한 이 해충의 피해와 경제적 중요성이 미미하였으나, 최근 체리와 블루베리의 재배가 확산되면서 일부 지역에서 큰 피해가 발생하고 있다. 2020~2022년에 걸쳐 국내 체리 과수원을 대상으로 벗초파리 발생분포를 조사한 결과, 이천, 예산, 완주, 곡성, 순천, 김천, 창녕, 하동, 경주에서 벗초파리 발생을 확인하였다. 벗초파리가 발생하는 6월 상순경과 중순경에 순천의 체리과원에서 아바멕틴 유제 약제를 살포하여 방제 효과를 조사하였다. 피해과율 조사시 1회 살포는 49%, 2회 살포 12.8%로 무처리 피해과율 93% 대비 효과가 좋았으며, 체리가 익어갈 때 주로 날아와서 피해를 주므로 농약의 안전사용일수를 확인하여 수확기 근처까지 살포할 수 있는 약제로 2회 살포하여 초파리를 방제하는 것이 효과적이다.

검색어: 벗초파리, 체리, 분포, 살충제, 방제

P225

Density and age of *Spodoptera frugiperda* larvae influences on *Meteorus pulchricornis* parasitism

Meeja Seo, In Hong Jeong, Dagyeong Jeong, Gwan Seok Lee, Jum Rae Cho and Hong Hyun Park
Crop Protection Division, National Institute of Agricultural Sciences, RDA

The solitary larval endoparasitoid, *Meteorus pulchricornis* showed 63.1% parasitism on average against *Spodoptera frugiperda* larvae in laboratory. However, parasitism of *M. pulchricornis* varied with different densities and developmental instars of host larvae. This parasitoid preferred to oviposit younger instar larvae than old ones. Among different host larva instars, on 3rd instar larvae of *S. frugiperda*, this parasitoid showed high parasitism with statistically significant difference. The number of parasitized larvae by *M. pulchricornis* increased proportionately with the host density.

Key words: larval parasitoid, parasitism, Braconidae, Noctuidae

P226

Spatial and temporal dispersion of Whitefly-Predators under different micro-climates in Paprika greenhouse

Meeja Seo[1], Jeong Hwan Kim[1] and Jong Suk Park[2]
[1]Crop Protection Division, National Institute of Agricultural Sciences, RDA
[2]Fruit Vegetables Research Institute, JBARES

Whiteflies and their predatory mite, *Amblyseius swirskii* densities were investigated in 660㎡ Paprika greenhouse from early March after planting in late February to late August. As a result of analyzing the environmental condition with the HOBO data logger installed at each point within the greenhouse, the maximum temperature at the initial occurrence point was 35.6℃, 1.3℃ lower than other points. Whiteflies began to occur in part at the end of March, but the pests were not captured at the point above 37℃ maximum temperature. As soon as the average relative humidity exceeded 60%, the number of whiteflies captured on yellow sticky traps began to dramatically increase. Relative humidity positively influences the densities of whiteflies and predatory mites. Maximum and average temperatures showed a significant negative effect on the density of predatory mites, *A. swirskii*.

Key words: Whitefly-predator dispersion, *Bemisia tabaci, Amblyseius swirskii*, Micro-climate

P227

Temperature-dependent development of *Mythimna loreyi*

Sunghoon Baek[1], Jin Kyo Jung[2], Eun Young Kim[2] and Chang-Gyu Park[1]
[1]Department of Agriculture and Fisheries Covergence, Korea National University of Agriculture and Fisheries
[2]Crop Cultivation and Environment Research Division, National Institute of Crop Science

뒷흰가는줄무늬밤나방은 국내에서 월동하지 못하는 비래해충으로 알려져 있으며, 최근 그 발생량이 증가하고 있는 해충이다. 이번 연구에서는 이러한 뒷흰가는줄무늬밤나방의 온도 의존적인 발육 모델을 개발하고자 하였다. 온도 모델은 15℃부터 35℃까지 5℃ 간격으로 5개 항온 온도 조건에서 발육 속도를 이용하여 개발하였다. 뒷흰가는줄무늬밤나방의 발육 속도는 선형 모델과 비선형 모델 모두에 잘 예측되었다. 1령, 2령, 3령, 4령, 5령, 6령, 전체 유충기간, 번데기의 발육 영점 온도는 각각 10.8, 10.2, 10.5, 11.0, 11.5, 9.7, 10.3, 11.7℃으로 추정되었으며, 발육에 필요한 온일도는 각각 42.2, 41.5, 38.5, 38.9, 52.1, 137.0, 344.8, 166.7 온일도로 추정되었다. 각 발육단계별 발육최적온도는 각각 32.6, 33.7, 31.9, 30.4, 30.4, 29.4, 29.6, 30.0℃으로 추정되었으며, 발육 상한 온도는 각각 38.8, 38.1, 38.1, 36.1, 35.7, 35.0, 35.0, 35.0℃으로 추정되었다. 이번 연구 결과는 뒷흰가는줄무늬밤나방의 기본적인 생태 정보를 제공에 거치지 않고, 외국에서 월동을 마치고 비래한 개체군의 다음 세대 발생 시기를 예측하는데 활용되어 질 수 있을 것으로 기대된다.

검색어: 뒷흰가는줄무늬밤나방, 발육모델, 발육영점온도, 발육최적온도, 발육상한온도

P228

Prediction of domestic habitability of *Procambarus clarkii* by ensemble species distribution modeling

Dae-Hyeon Byeon[1] and Wang-Hee Lee[1,2]
[1]Department of Biosystems Machinery Engineering, Chungnam National University, Daejeon, 34134, Korea
[2]Department of Smart Agriculture Systems, Chungnam National University, Daejeon, 34134, Korea

Procambarus clarkii is an ecosystem-disrupting organism that has recently introduced into South Korea. Because distribution of an alien organism is affected by climatic and enviormental variables of the habitat, we attempted to evluate the potential distribution of *P. clarkii* according to climate change by using two different algorithms; CLIMEX and random forest (RF). In the RF model, AUC and TSS were 0.825 and 0.695, respectively, and bio6, elevation, and bio1 had great importance in variable importance evaluation. The occurrence possibility was relatively low in Gangwon-do, Sobaek Mountains, and Jeju island, and it would not significantly change by climate change. The result of the CLIMEX was similar to that of the RF model, showing low climatic suitability in mountainou areas. By develping the ensemble model, 29% of the country was evaluated to be high-risky, but it would decrease to 24% in 2050 with similar distribution pattern.

Key words: CLIMEX, ensemble model, random forest, red swamp crawfish

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Occurrence of western conifer seed bugs from Incheon National University in 2022 and illustrations of each stages

Tak-gi Lee[1], Chang-Moon Jang[1], Jeong-Nam Kim[1], Dae-Seong Lee[2] and Yang Seop Bae[3]
[1]Division of Life Sciences, College of Life Sciences and Bioengineering, Incheon National Universtiy, Korea
[2]Department of Biology, Kyung Hee University, Seoul 02447, Korea
[3]Bio-Resource and Environmental Center, Incheon National University, Korea

Western conifer seed bug (*Leptoglossus occidentalis* Heidemann, 1910) is firstly recorded in 2010, Changwon-Masan region as an invasive pest insect. For the last 12 years, this species has dispersed to the almost over the country. Since 2018, western conifer seed bugs were observed and monitored by property of Incheon National University. In this study, we report the occurrence pattern from university property in this year. Additionally, we provide illustrations of egg, nymphs and adult.

Key words: *Leptoglossus occidentalis*, monitoring, nymph, morphological characters

P230

Monitoring of oviposition in rearing western conifer seed bugs

Tak-gi Lee[1], Chang-Moon Jang[1], Jeong-Nam Kim[1], Dae-Seong Lee[2] and Yang Seop Bae[3]
[1]Division of Life Sciences, College of Life Sciences and Bioengineering, Incheon National Universtiy, Korea
[2]Department of Biology, Kyung Hee University, Seoul 02447, Korea
[3]Bio-Resource and Environmental Center, Incheon National University, Korea

Western conifer seed bug (*Leptoglossus occidentalis* Heidemann, 1910) is a serious invasive pest of pine trees in recent years. This species mainly feed on cones of several coniferous trees including the genus *Pinus* L. In Korea, production of pine nuts of *Pinus koraiensis* Siebold & Zucc. were recently damaged seriously by western conifer seed bugs. Despite various attempts for pest control, there still remains concern because no pesticides officially registered in Korea, neither in the country of origin. In this study, we monitored spawning behavior of reared western conifer seed bugs using the alternative food with almond and pistachio.

Key words: *Leptoglussus occidentalis*, fertility, alternative food

P231

Co-occurrence of *Matsumuraeses falcana* and *M. phaseoli* (Tortricidae) larvae in soybean fields, and polymorphism in their DNA sequences of barcoding region

Jin Kyo Jung and Eun Young Kim
Crop Cultivation and Environment Division, Natl. Institute of Crop Science

Nucleotide sequences of the barcoding region of cytochrome oxidase I gene were acquired from larvae of *Matsumuraeses* sp. collected in soybean fields, and were compared with the reference sequences of *M. falcana* and *M. phaseoli* in laboratory stocks. Both species were identified from the samples simultaneously collected in the same fields in Baengnyeong and Yeoncheon, respectively. The results showed that the two species injured soybean, same organs of leaves and pods, at the same time. *M. falcana* was identified as the dominant species between the two insects. Ten variants with different nucleic acids on one or two positions (minimum 99.5% identity each other) were found in the sequences of *M. falcana*, whereas only one sequence(95.6~96% identities with *M. falcana*) was found in the samples of *M. phaseoli*. Amino acid sequences translated from all the sequences were identical in all samples of both species.

Key words: *Matsumuraeses falcana*, *M. phaseoli*, soybean, co-occurrence, partial COXI gene sequence

P232

Density and distribution of *Ricania shantungensis* (Hemiptera: Ricaniidae) nymph in sweet persimmon orchard

Da Gyeong Jeong, Hong Hyeon Park, Gwan Seok Lee, In Hong Jeong and Mi Ja Seo
Crop Protection Division, National Institute of Agricultural Science, RDA

갈색날개매미충은 농경지와 농경지 주변 산지를 이동하며 경제적 과수와 조경수 등에 피해를 주어 방제가 어려운 대표적인 돌발해충이다. 갈색날개매미충은 1년생 어린 나뭇가지를 뚫고 가지 속에 알을 낳아 가지 30~50%에 상처를 입히고 양분과 수분의 이동을 불량하게 한다. 또한, 약충과 성충은 작물의 수액을 빨아먹고 분비물을 배출해 그을음병을 일으켜 식물 생장을 방해한다. 2022년 사천 단감원 내 단감나무와 주변 기주식물에서의 갈색날개매미충 밀도와 분포를 6-10일 간격으로 조사하였다. 단감나무에서 갈색날개매미충 1령기 약충의 약 77%가 잎과 감꼭지에서 관찰되었으며, 2-4령기 약충은 대부분 감꼭지에서 관찰되었고, 5령기 약충의 약 79%가 줄기와 감꼭지에서 관찰되었다. 단감원 주변 기주식물인 매실나무, 대추나무, 복사나무에서 갈색날개매미충 약충은 대부분 줄기에서 관찰되었다. 이와 같은 결과는 갈색날개매미충의 이동과 관련된 기초 생태 연구에 참고 자료로 활용될 것으로 사료된다.

검색어: 갈색날개매미충, 단감나무, 밀도, 분포, 기주식물

P233

Analysis of distribution of major rice insect pests using forecasting fields information

Nak Jung Choi, Bo Yoon Seo, You Kyoung Lee, Sang-Min Kim, Soo Yeon Choi, Hyunjung Chung, Tae Hwan Noh and June-Yeol Choi
Crop Foundation Research Division,, National Institute of Crop Science

농촌진흥청은 벼에 가해하는 병해충 발생 예측을 통해 병해충 방제 정보를 제공함으로써 쌀을 안정생산하고자 전국 156개 시군 농업기술센터에서 예찰포를 운영 중이다. 다양한 예찰 장비 중에서 해충 예찰을 위해서는 유아등 트랩이 주로 활용되고 있다. 유아등 조사는 매년 5월 1일부터 8월 31일까지 4개월간 매일 실시하여 조사 결과를 국가농작물병해충관리시스템(NCPMS)에 등록하므로써 전국 발생상황을 실시간으로 확인할 수 있어 대책 수립에 활용되고 있다. 본 연구에서는 2000년부터 2020년까지의 벼 기본예찰일보를 바탕으로 유아등 조사 대상 해충인 혹명나방, 애멸구, 벼멸구, 흰등멸구, 벼물바구미, 먹노린재, 이화명나방, 멸강나방, 끝동매미충 등 총 9종의 지역별 분포를 분석하였다. 결과에 따르면, 비래해충 중 벼멸구는 남부 지방에 집중적으로 발생하는 반면, 혹명나방, 멸강나방, 애멸구, 흰등멸구는 전국적으로 발생하는 것으로 나타났다. 한편 같은 종이라도 지역별로 발생 양상이 다른 것으로 나타났다. 이 결과를 활용하면 벼 해충 예찰업무에 도움이 될 것으로 기대된다.

검색어: 벼, 해충, 예찰포, 유아등, 국가농작물병해충관리시스템

P234

An easy to distinguish between male and female silkworm, Yanghyeonjam

Seong Wan Kim
Department of Agricultural Biology, National Institute of Agricultural Science, RDA

농가소득 향상을 위해 기능성 양잠산물 생산용 누에품종의 육종 목표도 변화되고 있으며, 용도에 따라 혈당강하제용 누에분말, 누에 동충하초, 수번데기 생산용 등 다양한 누에품종이 육성되고 있다. 이러한 육종목표에 의해서 양친한성 품종인 양현잠을 육성하게 되었다.

양현잠은 2018년 춘잠기에 교배조합 능력검정을 통해 우수 교배조합으로 선발되어 2020년에서 2021년까지 춘·추잠기에 국립농업과학원과 전국 7개도 잠업 관련 기관과 공동으로 누에사육시험, 사질조사 및 동충하초 생산력 검정을 수행하였다. 국립농업과학원에서 원종의 특성조사, DNJ(1-Deoxynojirimycin) 함량 검정을 실시한 결과, 양현잠은 화용비율이 대조 품종보다 높은 강건성 품종으로 견사량 많고, 견층중이 무거운 다사량계 품종으로, 춘·추잠기의 품종으로서의 우수성이 인정되었다. 본 품종은 누에장려품종 지정심의회에서 교배조합 "JS227 × CS240"을 양현잠으로 명명하였고, 교배조합 각각의 원종명은 잠163과 잠164로 하여 춘·추잠기 누에장려품종으로 지정하였다.

검색어: 누에, 암수감별, 한성반문, 양잠, 동충하초

P235

Biological performance of *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) is differentially constrained by short-term exposure to high CO_2 concentration

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 short-term exposure to high CO_2 concentration (1000ppm) on development, longevity and fertility of *M. persicae.* We applied the computer programs – TWOSEX-MSChart and TIMING-MSChart - to analyze the data. We obtained the life table parameters and population projections using two computer programs.

Key words: *Myzus persicae,* Carbon dioixde, Life table parameters, Short-term exposure

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

P236

Two-phase oviposition model of *Zeugodacus cucurbitae* (Coquillett) (Diptera: Tephritidae)

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 melon fruit fly *Zeugodacus cucurbitae* infests fruit and vegetables of more than 125 plant species, predominantly those from the family Cucurbitaceae. We investigated the longevity and fecundity of *Z. cucurbitae* at five different temperatures and organized female oviposition model using two-phase oviposition model, which modified the logic structure of the current model by separating pre-oviposition. The results of the two-phase oviposition model provided more realistic outputs at lower and higher temperatures than those of the current model.

Key words: *Zeugodacus cucurbitae,* Fecundity, Longevity, Survivorship, Temperature

Acknowledgements: This research was supported by an international cooperative research project (PJ01420201)

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Analysis of the population parameters and growth on *Zeugodacus cucurbitae* (Coquillett) (Diptera: Tephritidae) using the age-stage, two-sex life table

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 melon fruit fly *Zeugodacus cucurbitae* is major invasive and polyphagous insect pest with a worldwide distribution. We investigated the development time, survivorship, longevity and fecundity of *Z. cucurbitae* at five different temperatures. We applied the computer programs, TWOSEX-MSChart and TIMING-MSChart, to obtain the population parameters and life table parameters. The highest intrinsic rate of increase and finite rate for *Z. cucurbitae* were observed at 32℃.

Key words: *Zeugodacus cucurbitae,* Life table parameters, Population projection, Temperature

Acknowledgements: This research was supported by an international cooperative research project (PJ01420201).

P238

Parameter Estimation for a Temperature-dependent Development Model of Chilli Thrips (*Scirtothrips dorsalis* Hood) on Satsuma Mandarin

Soon Hwa Kwon, Jaehong Kim, Yosup Park and Jaeho Joa
Citrus Research Institute, National Institute of Horticultural and Herbal Science, Korea

Scirtothrips dorsalis is an important citrus pest. A thorough understanding of the biology and population dynamics of *S. dorsalis* is essential for development of reliable pest population prediction system. We investigated the developmental periods of the species under ten constant temperature schemes(12.5℃~33℃). Furthermore, we established a development model of *S. dorsalis*, based on the result of a laboratory experiment. The immature developmental duration of *S. dorsalis* at constant temperatures shows statistically significant difference among temperature regimes. In relation to temperature, non-linear development models were established for each developmental stage of *S. dorsalis*.

Key words: *Phyllocnistis citrella*, temperature-dependent development, development model, citrus pestl

*This research was conducted with the support of the National Institute of Horticultural & Herbal Science and the Agenda Project (PJ01515001), RDA.

P239

Fungal insecticidal activity of *Metarhizium anisopliae* against Asian tiger mosquito, *Aedes albopictus*

Hoe Ri Kim[1], Hyunwook Jung[1], Hyngchan Kim[1], Jae Su Kim[2] and Se Jin Lee[1]
[1]Department of Agricultural Life Science, Sunchon National University
[2]Department of Agricultural biology, Jeonbuk National University

Asian tiger mosquito, *Aedes albopictus*, is the most important serious vectors of human diseases like malaria and is responsible for the transmission such as dengue fever and yellow fever in the world. Recently, entomopathogenic fungi have been used as an important control agent to control mosquitoes. Entomopathogenic fungi, which are environmentally friendly insect pest control agents and are used to control various pests. Herein, we assayed 10 entomopathogenic fungi against mosquito larvae and selected the fungal strains with high virulence. Based on these results, it suggests that entomopathogenic fungi can be control the mosquito larvae as an effective biopesticide.

Key words: asian tiger mosquito, *Aedes albopictus*, entomopathogenic fungi, fungal insecticide, *Metarhizium anisopliae*

P240

A study on the Status of Agricultural Population and Usage Status of Agricultural Antibiotics in Korea

Hyngchan Kim[1], Hoe Ri Kim[1], Hyunwook Jung[1], Jae Su Kim[2] and Se Jin Lee[1]
[1]Department of Agricultural Life Science, Sunchon National University
[2]Department of Agricultural biology, Jeonbuk National University

본 연구는 국내 농업인구 변화에 따른 농용 항생제 사용량 변화를 분석하는데 목적을 두었다. 이를 위해 2000~2020년 통계청 자료를 활용하여 농업 인구와 농업인의 중위연령을 조사하였다. 최근 20년간 국내의 농업인구는 감소하고 있으나 60세 이상 농업인은 증가함에 따라 국내 농업인의 중위연령이 높아지고 있는 추세이다. 최근 귀농의 대한 관심의 증가와 베이비붐 세대의 은퇴로 인해 귀농인수가 증가하고 있으며, 특히 2020년에는 30대 이하 귀농 가구수가 1,362가구로 역대 최대치를 기록하였다. 청년농의 증가 원인으로 영농정착지원사업 등 정책적 유인과 청년들의 인식의 변화 등이 있는 것으로 추정된다. 이처럼 새로운 귀농인들의 유입과 농업인의 고령화로 인하여 병해충에 대한 적절한 대응이 어려운 상태이다. 국내 등록된 농용항생제는 식물병 방제용 polyoxin, oxytetracycline, oxolinic acid, validamycin, streptomycin, kasugamycin과 해충 방제용 spinetoram, spinosad, abamectin, emamectin이 있으며, 농용 항생제의 전체 시장규모는 660억원으로, 연간 300톤 이상이 생산되고 약 100개 이상의 농작물에서 항생제 사용이 추천되고 있으나, 전문성 부족으로 인해 사용량 초과, 혼용, 중복사용 등 부적절한 사용의 사례가 빈번히 발생되고 있다.

검색어: 귀농, 농업인구, 농용 항생제, 농업인의 고령화

P241

Insecticidal control of nemadode (*Meloidogyne* spp.) in chinese yam (*Dioscorea opposita*) cultivation area

Shin-Hyuk Jo, Min-Ki Kim, Won-Kwon Jung, Il-Kweon, Yeon and Seok-Hee Park
Gyeongbuk agricultural research and extension service

Chinese yam (*Dioscorea opposita*) is a regional specialty crop in Andong, Gyeongsangbuk-do, and the cultivated area is 559ha, which is a major crop accounting for 76% of in the whole country cultivated area. The nematode (*Meloidogene* spp.) that occur on chinese yam are root-knot nematodes, which cause root knots or rot roots, which reduces the value of products and causes economic loss to farms. And occurrence of nematode by continuous cultivation is increasing every year, it is necessary to control them. In order to control of nematodes, before planting root-knot nematode-infected chinese yam soak by pesticide(fosthiazate (SL), dimethyl disulfide (SL)), NaOCL, and heat treatment and then seeded to test their effectiveness. And in order to investigate the effect of soil disinfection before planting, the effects of dimethyl disulfide (SL) and fosthiazate (SL) were treated and tested. As a result, it was possible to obtain an excellent control effect by showing more than 90% medicinal efficacy without any damage in fosthiazate (SL) + heating (51°C) treatment, and the soil disinfection effect showed 100% control effect in dimethyl disulfide (SL).

Key words: Chinese yam, nematodes, pesticide

P242

Buckwheat as a companion plant in soybean fields

Babatunde O. Kehinde, Young-gyun Park, Minhyeok Kwon,SouvicSarker,LaeunJang, Jong Hwi Baek and Un Taek Lim
Department of Plant Medicals, Andong National University, Korea

Several studies have examined the effects of companion plants to conserve indigenous populations of natural enemies in agricultural lands. In this study, to find a new companion plant for soybean, we investigated the effect of planting buckwheat on the population dynamics of arthropod pest and natural enemy species in soybean fields. The numbers of major pests and natural enemies were recorded at 9-10 days intervals from 20 soybean plants during the cropping season. The dominant pest species were *Riptortus pedestris* and *Medythia nigrobilineata* while the dominant natural enemy species were *Yemma exilis* and *Orius* sp. There was no significant difference in both pest and natural enemy populations between the fields with or without buckwheat. Potentials of buckwheat as companion plants were discussed.

Key words: Landscape structure, *Glycine max*, Conservation biological control, Arthropod, Non-crop habitat

P243

Effects of commercial insecticides on germination rate of *Beauveria bassiana* ARP14

Moses Otuba, Young-gyun Park, Md Rasel Raju and UnTaek Lim
Department of Plant Medicals, Andong National University, Korea

Beauveria bassiana ARP14, a native entomopathogenic fungus strain in Korea, is an effective microbial agent to control stink bugs and whiteflies. However, little is known about the compatibility of insecticides with *B. bassiana* ARP14. In this study, the effects of four commercial synthetic insecticides, each containing the active ingredients abamectin, spinosad, thiamethoxam, cypermethrin, and one organic insecticide containing the active ingredient azadirachtin, on the germination rate of *B. bassiana* ARP14 were tested. Our results indicate that the mean germination rate of fungus spores in the controls did not differ much from that of treatments. Therefore, those chemical insecticides could be used simultaneously with *B. bassiana* ARP14 in the management of insect pests after field evaluation in future studies.

Key words: microbial agent, biological control, entomopathogenic fungus, compatibility

P244

Control efficacies of metabolites from *Metarhizium pinghaense* 15R on several pests

Hanchan Park, Sungbok Ryu, Min Gi Kim, In Seong Hwang, Minwoong Jeong, Dae Min Lee, In Hyuk Jang, Yong-hyeok Yu, Taegeun Lee, Hae Rang Ko and Keedon Han
Biological Research Team, Sungbo Chemicals Co. Ltd

생화학농약은 자연계에서 생성된 천연 화합물을 추출하여 이용하는 등 천연자원으로부터 기원한 생물 농약을 의미한다. *Metarhizium pinghaense*은 녹강균으로 알려진 *M. anisopliae*와 분류학적으로 매우 유사한 토양미생물로 곤충병원성 곰팡이이다. *M. pinghaense*은 destruxin이라는 대사물질을 생산한다. 이는 나비목, 파리목 등 해충에 대하여 약효가 있다고 보고되어 있다. 본 시험은 목화진딧물과 복숭아혹진딧물과 무테두리진딧물, 파밤나방, 점박이응애를 채집, 실내 사육 후 *M. pinghaense* 15R 배양여액에 대한 약효를 확인하기 위한 기초자료로써 활용하고자 시험을 수행하였다. 진딧물은 성충, 파밤나방은 2~3령 유충, 점박이응애는 암컷 성충과 약충을 대상으로 하여 진행하였다. *M. pinghaense* 15R 균주를 Sabouraud broth에 기본으로 하여 shaking incubator에서 150rpm 조건으로 6~8일 간 배양 후 filter paper로 여과를 하여 시료를 제조하였다. 목화진딧물, 복숭아혹진딧물, 무테두리진딧물은 배양여액에 대하여 경엽처리 5일 후 90% 이상의 방제가를 나타냈다. 파밤나방은 배양여액 침지처리 7일 후 80%의 방제가를 보였다. 또한, 점박이응애는 경엽처리 2일 후 암컷 성충과 약충 모두 97% 이상의 방제가를 나타냈다. *M. pinghaense* 15R 배양여액을 DCM으로 액-액 분배하여 HPLC로 분석하여 destruxin 함량을 확인하였다. *M. pinghaense* 15R의 대사물질인 destruxin은 진딧물류, 파밤나방, 점박이응애에 대하여 약효를 확인할 수 있으며, 이는 다양한 해충군에 대하여 생화학농약으로서 가능성이 있다고 판단된다.

검색어: *Metarhizium pinghaense*, destruxin, 진딧물, 파밤나방, 점박이응애

P245

Virulence Assay of Entomopathogenic Fungus *Metarhizium* for the Microbial Control of *Ramulus mikado*

Gun-Hyung Kwon, Min-Seop Lee and Sun-Hee Kim
Gyeonggido Forestry Enviroment Research Center

대벌레(*Ramulus mikado*)는 1990년 이후 산림에서 돌발적으로 발생하여 피해가 발생하고 있다. 최근에는 서울의 은평구 봉산, 경기도 의왕의 청계산, 경기도 군포시의 수리산 등 도심과 가까운 산림지역에서 대발생하여 피해를 주고 있다. 대벌레의 방제를 위해 끈끈이트랩과 약제살포 등의 방제가 이루어지고 있으나, 산림지역내에서 효율적인 방제를 기대하기 어려운 실정이다. 대벌레의 생물적 방제를 위해 곤충 병원성 곰팡이에 대한 병원성을 검정하였다. 곤충병원성 곰팡이는 2021년 대벌레 피해가 대발생한 경기도 의왕시 청계산 지역에서 폐사한 대벌레를 채집하여, *Metarhzium quizhouense*와 *M. anisopliae* 2종의 곤충병원성 곰팡이를 분리 동정하여 병원성 검정에 활용하였다. 병원성 검정을 위해 사육한 대벌레 성충을 대상으로 각 균주를 1×10^5 conidia/㎖의 농도로 먹이식물인 콩잎에 살포하고, 대벌레 충체에 붓으로 직접적으로 도포하였다. 살포 후 2균주 모두 11일차에 전부 살충되어 대벌레에 대한 병원성을 확인할 수 있었으며, 특히 *M. anisopliae*를 잎에 분무한 처리구는 5일차에서부터 초기 살충효과가 우수한 것으로 나타났다. 처리방법별 비교에서는 2균주 모두 충체도포 보다는 먹이식물에 살포가 살충효과가 조금 더 빠르게 나타났다.

검색어: 대벌레, *Metarhzium quizhouense, Metarhzium anisopliae*, 곤충병원성 곰팡이

P246

Investigation of pest control methods and Phytotoxcity 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 백합과 알리움 속에 속하는 식물로 과거부터 약용식물로 쓰여져 왔으며, 현대에는 양념채소로 재배 및 소비되고 있다. 마늘은 영양체 작물이기 때문에 바이러스의 수직감염에 굉장히 취약한 특성을 보인다. 마늘의 주아를 종구로 사용했을 때 바이러스의 감염율이 낮아지고, 수세가 회복 된다는 연구문헌에 따라 농가들은 주아 재배를 시행하고 있는 실정이다.

마늘의 주아에는 파좀나방, 파총채벌레 등의 해충이 발생된다는 보고가 있으나, 해충 생태와 방제법에 대한 대한연구가 미비한 실정이다. 본 연구에서는 마늘에 발생되는 해충의 발생생태와 주아 해충의 피해를 경감시키기 위해서 수확 후 주아 절단방법별 침지소독후 해충의 발생밀도를 관찰하였다.

관찰결과 파총채벌레, 파좀나방 등 2종의 해충이 발생하였으며, 파좀나방은 8월상순 파총채벌레는 7월중순까지 출현하였고, 그 이후 발생은 조사되지 않았다. 3종 약제를 처리하였을 때 방제가가 90% 이상 관찰되어 밀도 감소 효과가 있었으며, 약제 침지된 주아를 파종하였을 때, 약해는 관찰되지 않았다.

검색어: 마늘, 주아, 저장, 파총채벌레, 파좀나방

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Development of management tools for controlling invaded insect pests by double-stranded RNAs

Nguyen Minh Anh Hoang[1], Min-Young Kim[2] Hong-Hyun Park[3] and Young Ho Koh[1,2]
[1]ILsong Institute of Life Science, Hallym University, Seoul, Korea
[2]Department of Biomedical Gerontology, Hallym University, Chooncheon, Korea
[3]Crop Protection Division, National Institute of Agricultural Science, Wanju, Korea

Crop protection agents currently used have problems such as inducing pesticide resistance to target insects when they are repeatedly and excessively used or damaging non-target beneficial insects, animals, and plants. Recently, double-stranded (ds) RNAs have been shown to control target insect pests with great species specificities. In this study, we present and discuss the results of our recent studies using ds-RNAs for controlling invaded insect pests such as fall webworms (Grant No. J014845032022).

Key words: Fall webworms, double-stranded RNAs, management, species-specificities

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Scaled-up fumigation using ethyl formate for passionfruit under plantation and post-harvest conditions against *Aphis spiraecola*

Tae Hyung Kwon[1], Dong Bin Kim[1], Jung-joon Park[2,3] and Byung-Ho Lee[1]
[1]Institute of Quality and Safety Evaluation of Agricultural Products, Kyungpook National University, Daegu
[2]Institute of Agriculture and Life Science, Gyeongsang National University, Jinju
[3]Department of Plant Medicine, Gyeongsang National University, Jinju

As the plantation of subtropical crops increases in South Korea, the damage to insects pests is also increasing. In case of insect pests that damage tropical fruits, they overwinter in a vinyl house, so both the plantation and post harvest conditions must be disinfected. Passionfruit (*Passiflora edulis*) is an important ingredient for juice and wine as its rich aroma and various nutrients. In this study, the efficacy of ethyl formate (EF) as methyl bromide (MB) alternatives was evaluated against *A. spiraecola*, a insect pests commonly detected in passionfruit. Based on efficacy data, scaled-up fumigation were conducted on passion fruit under plantation condition (Vinyl house) and post-harvest condition for domestic distribution. It was carried out 100% mortality of insect pests, and there was no phytotoxic damage.

Key words: ethyl formate, altetnatives, passion fruit, cultivation condition, storage condition

P249

Control of Varroa destructor via RNA interference: lethal effects of knockdown of coatomer proteins

Keon Mook Seong[1], Hoe Nan Jeong[2] and Rashmi Manohar Mahalle[3]
[1]Department of Applied Biology, Chungnam National University
[2]Department of Vector Entomology, Kyungpook National University
[3]Institute of Agricultural Science, Chungnam National University

RNA interference (RNAi) is an efficient approach as a potential strategy for selectively controlling pests. The Varroa mite, (*Varroa destructor*), is the worst threat to honey bee health worldwide. To explore the possibility of using RNAi to control this pest, we determined the effects of knocking down genes encodes a subunit of the cytoplasmic coatomer protein complex on varroa mite survival. Injection of dsRNA for COPB, COPD, and COPE caused a significant reduction in Varroa mite survival based on lethal time 50 (hour) after post-injection (hpi), respectively as compared to control mites injected with green fluorescent protein (GFP)-dsRNA, water, and untreated mites. Knockdown of the target genes was verified by qrt-PCR for three genes important for survival. Our finding indicate that coatomer proteins play an important role in the survival, suggesting that these genes could explored as a potential target for the development of RNAi-based control strategies in Varroa mite in the future.

Key words: RNA interference, Varroa destructor, Hony bee, Coatomer protein, Gene knockdown

P250

Occurrence probability of pine wilt disease predicted by three different algorithms

Sunhee Yoon[1], Jae-Min Jung[2], Donghyeon Kim[2], Jinhyeong Hwang[3], Yuri Park[3] and Wang-Hee Lee[1,2*]
[1]Department of Smart Agriculture Systems, Chungnam National University
[2]Department of Biosystems Machinery Engineering, Chungnam National University
[3]Division of Monitoring & Analysis, Forest Pests & Diseases Monitoring Headquarters, Korea Forestry Promotion Institute

Pine wilt disease (PWD) is a notorious *Pinus* disease that has caused severe economic and ecological losses in South Korea. In this study, the potential distribution of PWD in South Korea was predicted by using three different species distribution models; MaxEnt, random forest (RF) and deep feed forward network (DEF). Each model was developed based on actual occurrence records of PWD surveyed from 2016 to 2020, and operated with bioclimatic variables coded by using the monthly climate data. As a result, the occurrence possibility was evaluated and concentrated around the occurrence records that are largely distributed in the middle and southeast parts of South Korea. In addition, compared to previous model with monthly climatic data, this model with bioclimatic variables showed higher model performance.

Key words: bioclimatic variable, deep learning, machine learning, occurrence possibility, pine wilt disease

P251

Studis on labor saving-pesticide application method to control *Thrips palmi*

Minjun Kim, Jongmin Lee, Huijun an, Minju Kim, Chan Park and Yongoh Jang
Crop protection R&D center, Farmhannong Co., LTD, Korea

최근 시설원예 농가에서 총채벌레류 살충제 약효 미흡이 이슈된 바 있다. 저항성이 원인인 농가 이외의 경우를 확인한 결과, 고농도 저물량으로 약제가 처리됨을 확인하였다. 일반적으로 원예작물은 ha당 2000L의 물량을 사용하나, 이슈 농가들은 ha당 약 1000L이하로 처리되고 있었다. 이를 주요 원인으로 추정하고, 물량별 차이를 검증하였다. 검증은 오이총채벌레를 대상으로 Broflanilide+Emamectin benzoate 4.5+2.15% EC 제품을 사용하였다. 면적 당 동일 약량의 약제를 ha당 2000L, 1000L 처리시 각 97.4%, 72.4%의 방제가를 나타내어 물량이 적으면 활성이 떨어짐을 확인하였다.

저물량 살포의 대안으로 생력화 처리방법인 연막처리 적용 가능성을 검토하였다. 시험결과 경엽처리 97.1%, 연막처리 96.6%의 방제가를 나타내어 경엽처리 대비 비등한 수준으로 나타났다. 뿐만 아니라 담배가루이에서 각 92.1%, 89.3%, 담배거세미나방에서 두 처리군 모두 100%의 방제가를 나타내어 본 연구에 적용된 본 제품의 경우 연막처리가 저물량 살포의 대안이 될 수 있는 가능성을 확인하였다.

검색어: 오이총채벌레, 연막처리, 생력화, 살포물량

P252

Laboratory Testing: Differences between contact and feeding of *Spodoptera frugiperda* insecticides

Kyeong Rin Bang, Mi Ran Hwang, Heon Seop Won, Kwang Jae Lee, An Soo Lee, Jae Hong Lee and Jae Young Ko
Gangwondo Agricultural Research and Extension Services

열대거세미나방은 편서풍을 타고 비래하는 해충으로 2019년 국내 최초 유입된 것으로 확인되고, 2019년 6월 제주에서 처음 발견된 이후 보통 4~6월에 제주에서 처음 발생되어, 남부지방부터 중부지방으로 확산되는 양상을 보인다. 강원도내 비래한 열대거세미나방을 조사한 결과 강원도는 남부지방에 비해 약 1달 ~2달 정도 느린 7월 초·중순 정선일대에서 처음 발생되어 동해·영월·홍천으로 확산되는 양상을 보이고 있다. 열대거세미나방은 발생 즉시 약제 방제가 중요하다. 현재 옥수수를 기준으로 열대거세미나방에 효과 있는 섭식·접촉 모두 효과있는 약제 5종을 선택해서 약제에 접촉만 했을 때와 섭식만 했을 때, 그리고 3령 이하 유충과 4령 이상 노령유충에 약제 방제효과의 차이점을 알아 본 결과 접촉보다는 섭식했을 때 효과가 더 좋고, 3령 이하보다 노령유충에도 충분한 효과가 있는 것을 확인 하였다. 밀도가 높으면 서로 포식하는 습성과 낮에는 잎안에 숨어있다 밤에 밖에 나와 가해하는 습성을 생각하면 작물에 골고루 약제만 살포하여도 충분히 방제효과가 있는 것을 확인 할 수 있었다.

검색어: 열대거세미나방, 강원도, 비래해충, 옥수수 해충, 약제방제

P253

Confirmation of plant extract activity against *Spodoptera frugiperda*

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

Spodoptera frugiperda is a pest that injures more than 80 species of plants, causing great damage to economically important crops. We formed a complex make use of Met (methoprene tolerant), known as a juvenile hormone receptor, and SRC (steroid receptor coactivator), which forms a heterodimer. The plant extract activity was analyzed through screening using the met/SRC complex. In the plant extract activity assay, we tested 100 plant extracts in transformants bearing Met and SRC. We identified 7 plant extracts with high JH disruptor (JHD) activity in *Spodoptera frugiperda*, and bio-assayed using the identified substances. Based on these results, the selected substances show potential as eco-friendly agents for use in the future.

Key words: *Spodoptera frugiperda*, Juvenile hormone, Methoprene-tolerant, SRC, Plant extract

P254

Insecticidal efficacy of natural plant extracts against green peach aphids and two spotted spider mites

Ju Yeon Park, Song Hee Han and Chul Hong Kim
Hyunnong CO., LTD

It is necessary to develop new natural pesticides and replace existing chemical pesticides because pesticide resistance is continuously increasing due to excessive use of chemical substances. Here we studied about insecticidal efficacy of natural plant extracts against peach aphids and tow spotted spider mites. 14 kinds of plant extracts were tested for insecticidal activity. Torilis japonica, rheum undulatum, clove, shrubby sophora, cinnamomum cassia were good candidate for natural pesticides against aphid and mite. Especially, clove and shrubby sophora showed more than 80% insecticidal ability at 3day after treatment. We expect to be able to develop new natural plant protection agents based on these studies

Key words: natural plant extracts, bark beetle, green peach aphid, two spotted spider mite

P255

Natural enemy use characteristics for environment-friendly cultivation of red pepper in greenhouse

Seon-U Choi, Sang-Young Seo, Hyo-Jung Choi and Min-Sil Ahn
Jeollabuk-do Agricultural Research and Extension Services

There are cases of successful pest control using natural enemies in greenhouse red pepper cultivation, focusing on eco-friendly farmers in Jeollabuk-do. In red peppers, eco-friendly pest control should be carried out by adding fruits along with leaves. The 4 problematic pests, such as whiteflies, aphids, leaf mites, and thrips, mainly damage leaves. They can be controlled using natural enemies. However, in the case of aphids, control is difficult if initial release is delayed. *Helicoverpa* spp. causing damage to fruits are still difficult to apply to natural enemies. For *Helicoverpa* spp. control, we need installation of insect screen net, spraying organic agro-materials such as *Bacillus thuringiensis*, and moth mating disruption agents. We intend to present a field application model based on the results of analyzing the factors occurring in the field.

Key words: red pepper, greenhouse, environment-friendly cultivation, natural enemy

P256

Screening for effective organic farming materials for the control of *Planococcus citri*

A-Hae Cho, Duck-Soo Choi, Hyo-Jeong Kim and Jin-Hee Lee
Environment-Friendly Agricultural Research Center, Jeollanamdo Agricultural Research and Extension Services

귤가루깍지벌레(*Planococcus citri*)는 패션프루트(*Passiflora edulis*)의 가지 사이나 겹쳐진 잎 사이, 과실과 잎의 겹쳐진 틈 등에 집단적으로 서식하여 피해를 주며, 배설물로 그을음병이 유발되어 과실의 상품 가치를 저하시키는 해충이다. 전남지역 패션프루트 재배 농가의 병해충 발생 조사 결과 귤가루깍지벌레가 주요 해충이었다. 귤가루깍지벌레의 친환경 방제를 위하여 효과적인 유기농업자재를 선발하였다. 고삼추출물 90% 등 10품목의 유기농업자재를 대상으로 방제효과 실내검정을 3반복 실시하였다. 유기농업자재는 마늘추출물 80% 등 3종이 방제가 61.4% 이상 효과가 있었다.

검색어: 귤가루깍지벌레, 패션프루트, 유기농업자재, 방제

P257

Susceptibility of Red pepper chemical insecticides to *Frankliniella occidentalis*

Jung Beom Yoon, Sun Young Lee, Mi Hye Seo and Seong Chan Lee
Horticultural & Herbal Crop Environment Division, National Institute of Horticultural and Herbal Science, RDA

꽃노랑총채벌레는 고추, 토마토, 참외, 상추 등의 채소뿐만 아니라 화훼, 과수, 약용작물 등 거의 모든 작물을 가해하고 토마토반점위조바이러스(TSWV), 국화줄기괴저바이러스(CSNV), 봉선화괴저반점바이러스(INSV) 등을 매개하여 작물 생육, 상품성 저하, 수확량 감소를 초래하고 그 피해가 확산되고 있다. 총채벌레 방제를 위한 장기간 무분별한 화학 약제 사용이 약제 저항성 발현 개체 출현과 다른 약제에 대한 교차저항성 유발로 점차 사용할 수 있는 살충제 종류가 감소하여 농가 현장에서는 이로 인한 약제 효력 저하에 대한 의구심 증대와 함께 해충 방제의 어려움을 호소하고 있다. 고추에 등록된 유기합성 살충제 39종에 대한 꽃노랑총채벌레의 약제 감수성을 실내 검정한 결과 deltamethrin(합성피레로이드계)+profenofos(유기인계)를 함유한 살충제가 살포 1일 후 성충, 약충 모두 다 100%, clothianidin(네오니코티노이드계)+spinetoram(스피노신계)는 성충 97%, 약충 92%, imidacloprid(네오니코티노이드계)+spinetoram(스피노신계)는 성충 98%, 약충 92%,의 살충력을 보였다. 꽃노랑총채벌레의 발생 밀도가 높을 경우 이러한 속효성 약제 살포로 효율적인 방제가 가능할 것으로 판단된다.

검색어 : Wsetern flower thrips, Insecticide, deltamethrin+profenofos

P258

Control of *Eurytoma maslovskii* in *Prunus mume* using the mating disruption technique

Jung Beom Yoon, Seong Chan Lee, Sun Young Lee, Mi Hye Seo and Chang Yeol Yang
Horticultural & Herbal Crop Environment Division, National Institute of Horticultural and Herbal Science, RDA

복숭아씨살이좀벌(Eurytoma maslovskii Nikolskaya)은 매실, 살구, 자두 등 핵과류의 종자를 가해하여 과실의 상품가치를 떨어뜨리고 줄기를 마르게 하여 큰 경제적 손실을 유발하는 해충으로 매실의 경우 성충이 4월부터 발생해 매실 열매 속에 산란을 하고 약 15일 후 부화 유충이 매실 씨방을 먹고 자란다. 이렇게 피해를 본 매실은 껍질이 썩어 마르면서 함몰되거나 수확 전에 낙과가 많아진다. 매실 주산지인 전남지역에서는 최근까지 재배면적의 30% 이상 피해를 입었으며 매실 재배농가는 복숭아씨살이좀벌 방제를 위해 8~10회 약제를 살포하나 방제효과가 미미하다. 광양 매실 재배농가에서 복숭아씨살이좀벌의 성페로몬인 2,10-dimethyldodecyl propionate와 2,8-dimethyldecyl propionate을 조합한 교미교란 방제효과를 조사한 결과 무처리 77% 이상의 과실 피해를 보였으나 성페로몬 시험구에서는 36%의 과실 피해가 보여졌다.

검색어 : *Eurytoma maslovskii*, *Prunus mume*, mating disruption

P259

Susceptibility of chemical insecticides to *Tetranychus urticae Kochi*

Jung Beom Yoon, Sun Young Lee, Mi Hye Seo and Seong Chan Lee
Horticultural & Herbal Crop Environment Division, National Institute of Horticultural and Herbal Science, RDA

점박이응애는 기주범위가 넓어 고추, 파프리카, 가지, 수박, 오이, 참외, 멜론, 딸기, 토마토 등의 과채류 외에도 국화, 장미 등의 화훼류, 사과, 복숭아 등의 과수류, 콩류, 약초류 등 다양한 작물을 흡즙하여 생육, 상품성을 저하하고 특히 겨울철 참외, 딸기, 토마토, 오이 등 고수익 시설작물에 큰 피해를 준다. 점박이응애 방제를 위한 장기간 무분별한 화학 약제 사용이 약제 저항성 발현 개체 출현과 다른 약제에 대한 교차저항성 유발로 점차 사용할 수 있는 살비제 종류가 감소하여 농가 현장에서는 이로 인한 약제 효력 저하에 대한 의구심 증대와 함께 해충 방제의 어려움을 호소하고 있다. 고추에 등록된 유기합성 살충제 39종에 대한 점박이응애의 약제 감수성을 실내 검정한 결과 deltamethrin(합성피레로이드계)+profenofos(유기인계)와 abamectin(아버멕틴계)+sulfoxaflor(설폭시민계)를 함유한 살충제가 살포 1일 후 100%, acetamiprid(네오니코티노이드계)+emamectin benzoate(아버멕틴계)는 88%의 살충효과를 나타냈다. 점박이응애의 발생 밀도가 높을 경우 이러한 속효성 약제 살포로 효율적인 방제가 가능할 것으로 판단된다.

검색어 : Two spotted spider mite, Insecticide, deltamethrin+profenofos, esfenvalerate

P260

Insecticidal Effects of Domestic Natural Plant Extract on Major Pests in Horticultural Crops

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

유기농업자재 제조 원료가 되는 주요 식물추출물은 제충국, 고삼, 데리스, 님 등으로 대부분 국외에서 수입에 의존하고 있는 실정으로 제품수급, 효용성 및 안전성 등에 빈번한 문제가 발생되고 있다. 이러한 문제점을 해결하기 위하여 제충국, 고삼, 차나무, 때죽나무 등 국내 자생식물의 에탄올추출물로 원예작물 주요해충인 담배거세미나방, 파밤나방, 점박이응애 등에 대한 살충효과를 조사하였다. 식물추출물 제조방법은 추출원료 300g에 70% 에탄올 2700ml을 넣고 60℃에서 3시간 고온추출 후 냉장보관하며 사용하였다. 담배거세미나방은 대부분의 식물추출물에서 살충력이 낮은 경향으로 50배 단독처리에서 50% 미만으로 낮았지만 천연유화제를 혼합하여 처리한 경우 진딧물, 응애류의 살충효과가 다소 향상되었다.

검색어: 자생식물, 식물추출물, 해충, 살충효과

P261

A comprehensive management method of rice paddies to prevent inflow and outflow of Golden Apple Snail (*Pomacea cannaliculata*)

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 우리나라 벼 친환경 재배에 있어서 제초제 대신 논 잡초 재거수단으로 가장 경제적이고 효율적인 방법으로 30여 년간 사용한 방법이다. 최근 환경부의 생태계 교란생물 지정과 관련하여 농림축산식품부에서는 논 투입 왕우렁이의 생태계 유출방지를 위하여 의무적으로 수거하도록 하였다. 따라서 본 연구에서는 논 투입 왕우렁이의 유입·유출방지를 위한 시기별 논 관리방법을 제시하고 그에 따른 수거량과 생태계 유출방지효과를 조사하였다. 왕우렁이 유출입방지를 위하여 이앙 전 논두렁을 정비하고 입수구에 구리테이프부착망을 설치하여 물과 함께 들어오는 우렁이를 차단하였으며, 배수구에는 개량물꼬를 설치하여 유출을 차단하였다. 중간물떼기시 논 가장자리에 물길을 조성하여 왕우렁이 수거결과 45%가 수거되었으며, 수확전 논 건조시 2차로 수거하면 80% 이상 수거 가능할 것으로 판단된다.

검색어: 왕우렁이, 유입방지, 유출방지, 논 종합관리방법

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Golden Apple Snail (*Pomacea cannaliculata*) Killing Effect of Several Plant Extracts

Duck-Soo, Choi, Hyo-Jeong Kim, A-Hae, Cho , Jin-Hee, Lee, Hyeon-Ji, Kim and Ji-In Kim
Environment-friendly Agricultural Research Institute, JARES, Jeonmam 58213, Korea

왕우렁이(*Pomacea canaliculata*)가 국내에서 논 제초제 대용으로 사용된지 30여년이 지나면서 내한성 이 발달하여 해에 따라 월동 후 생존개체에 의한 벼 어린모 피해가 발생하는 실정이다. 왕우렁이의 생태계 유출방지 및 월동 왕우렁이에 의한 벼 피해를 방지하기 위하여 친환경 방제수단이 필요하다. 현재 유기농업자재로 등록된 왕우렁이 방제제는 황산동, 차추출물제 등 6종이 있는데, 이들의 살패효과를 조사하였고 알의 부화를 억제시킬 수 있는 자재를 선발하였다. 또한, 차나무, 동백나무, 자리공, 때죽나무 열매 등 식물체 에탄올추출물의 왕우렁이 살패효과를 조사하였다. 기존 생산된 유기농업자재 중 왕우렁이 방제에 효과적인 유기농업자재는 황산동, 차추출물제, 님추출물제 등 3종이 80% 이상 방제효과가 있었고, 천연유화제 5배, 빙초산 15배처리는 부화억제효과가 높았고, 차나무, 때죽나무, 자리공 에탄올추출물의 왕우렁이 살패효과가 높았다.

검색어: 왕우렁이, 식물추출물, 살패효과, 방제

P263

Interactive effects of application time and cross treatment of pesticides in soybean plant for the management of Spodoptera exigua (Hubner)

Seo yeon Hong, Hwi Jong Yi, Rameswor Maharjan, Young Nam Yoon and Yun Woo Jang
Department of Southern Area Crop Science, National Institute of Crop Science, RDA

콩 재배지에서 파밤나방이 대발생되고 있으나 동일 약제 연용함에 따라 해충의 저항성이 증가될 우려가 있다. 본 연구는 살충제의 처리시기, 횟수, 교차살포에 따른 효과를 비교하였다. 2021년 국립식량과학원 남부작물부 시험포장에서 수행하였으며 청자5호 품종을 사용하였다. 파밤나방 트랩조사 시 7월 5일, 8월 5일, 9월 15일 시기 성충이 다발생하였으며 6월 하순, 8월 상순, 9월 초순 최성기 전후로 약제를 처리하였다. 처리 횟수 및 교차살포에 따른 살충효과를 비교하기 위해 세대별 1~2회 변량 처리하였고 1차 인독사카브, 2차 에마멕틴벤조에이트, 3차 루페뉴론을 각각 살포하였다.

그 결과 살충제 교차살포 및 단일 살포에 따른 피해율 차이는 없었지만 무처리의 피해율은 10% 높았다. 7일 간격으로 2회 반복 처리하였을 때 살포횟수에 따른 피해율 차이는 없었다. 무처리의 피해율은 10%이상 차이가 났다. 살충제 처리횟수나 방법에 따른 수량은 차이가 나지 않아 약제별 처리효과 구명에 어려움이 있어 2022년 반복 실험중이며, 접종구 및 무처리구 간 비교실험 추가 진행하고 있다.

검색어: 파밤나방, 방제, 복합처리, 교차살포

P264

Host plants preference of the *Spodoptera frugiperda* larvae and the comparison of its control effect by chemical spraying method

You Kyoung Lee[1], Nak Jung Choi[1], Hyun Ju Kim[2], June Yeol Choi[1] and Bo Yoon Seo[1]
[1]Crop Foundation Research Division, National Institute of Crop Science
[2]Technology Transfer Division, National Institute of Crop Science

열대거세미나방(*Spodoptera frugiperda*)에 의한 작물 피해를 최소화하고자 벼과 식물 6종(벼, 기장, 옥수수, 수수, 피, 조)에 대한 기주 섭식량을 확인하고, 사료용 옥수수 포장에서 약제 살포방법에 따른 방제효과를 조사하였다. 3령~6령 유충을 대상으로 기주 섭식량을 3일간 확인한 결과, 옥수수에서 가장 많은 섭식량을 나타내었고 유충의 무게 증가는 옥수수 > 피 > 기장 > 수수 > 조 > 벼 순으로 나타났다. 이는 국내 열대거세미나방이 주로 옥수수에서 채집되는 결과와 상응하는 것으로 생각된다. 한편, 옥수수의 열대거세미나방에 등록된 인독사카브 액상수화제와 클로란트라닐리프롤 입상수화제를 대상으로 사료용 옥수수 출사 전 인력방제와 항공방제를 각각 7일 간격으로 2회 실시한 결과, 인력방제의 효과가 평균 67.4% 높은 것으로 나타났다. 열대거세미나방은 출사 전 신초 속이나 지제부 근처에 주로 분포하므로 항공방제 시 약제 노출 가능성이 떨어지기 때문인 것으로 생각된다. 이에 따라 노동력 부족으로 항공방제 등 인력방제 대체수단을 많이 사용하는 최근 상황에서 방제 효과를 제고할 수 있는 방안 마련이 필요한 것으로 사료된다.

검색어: 열대거세미나방, 기주섭식량, 인력방제, 항공방제, 방제가

P265

Effect of reflective film mulching for the control of *Frankliniella occidentalis* in pepper greenhouse cultivation

Mi Hye Seo, Seong Chan Lee, Sun-Young Lee and Jung Beom Yoon
Horticultural & Herbal Crop Environment Division, NIHHS, RDA, Korea

총채벌레는 고추의 열매 끝부분에 부착된 꽃잎 밑에서 가해하여 검은색의 가해흔을 남기며 고추가 붉게 변해감에 따라 피해 부위가 백색으로 변색되어 상품가치가 하락되게 된다. 또한, 직접적인 섭식 피해 이외에 토마토반점위조바이러스(TSWV)를 매개하는 간접적인 피해도 유발한다. 이러한 문제를 해결할 수 있는 새로운 대안으로 2021년 고창과 합천의 고추 하우스에서 12가지 색상 트랩을 설치하여 총채벌레 포획량을 비교한 결과, 검은색, 분홍색, 빨간색 트랩에서는 거의 포획되지 않아 상대적으로 기피 효과가 높은 것으로 조사되었다. 이러한 결과를 토대로 반사필름, 검은색, 빨간색의 멀칭필름을 재료로 이용하여 바닥에 설치한 뒤 고추를 정식하여 총채벌레의 발생 밀도를 조사하였다. 반사필름, 빨간색, 검은색 순서로 총채벌레의 발생 밀도가 낮았다. 약제 방제는 하지 않았으며 특히, 반사필름의 경우 2배 이상 밀도가 낮게 나타났다. 현재 반사필름이 고추 생육에 미치는 영향에 관한 조사가 진행중에 있으며 추후 총채벌레의 방제를 위해 효과적으로 활용될 것으로 기대한다.

검색어: 고추, 총채벌레, 반사필름, 밀도, 억제

P266

Effect of *Paeonia suffraticosa* for the control of *Frankliniella occidentalis* that occur on red pepper

Mi Hye Seo, Seong Chan Lee, Sun-Young Lee and Jung Beom Yoon
Horticultural & Herbal Crop Environment Division, NIHHS, RDA, Korea

총채벌레는 우리나라에 60여 종이 알려져 있으며 다양한 시설작물에서 직접적인 섭식 피해 이외에 토마토반점위조바이러스(TSWV)를 매개하는 간접적인 피해도 유발한다. 그동안 총채벌레 방제는 살충제에 의존해 왔는데, 이는 농업환경에 많은 부작용을 유발하고 해충에 저항성을 유발시켜 더욱 방제를 어렵게 하고 있다. 이러한 문제를 해결할 수 있는 대안으로 내성 회피를 위한 물질을 선발하였다. 실내검정으로 약용작물 67종을 추출하여 꽃노랑총채벌레 성충에 처리한 결과 목단피 추출물을 처리 후 1일차에 100%의 살충효과를 보였다. 또한, 목화진딧물은 3일차 83%, 복숭아혹진딧물 3일차 97%, 점박이응애 1일차 100%의 살충효과를 보였다. 고추 포트 검정에서 꽃노랑총채벌레 방제가는 1일차 77.6%, 2일차 40%의 효과가 나타났다. 현재 추가적으로 효과를 증대시킬 수 있는 물질을 탐색하고 있으며, 총채벌레 방제에 본 추출물을 활용한다면 효과적일 것으로 기대된다.

검색어: 고추, 총채벌레, 목단피, 방제

P267

Monitoring of major insect in Field-Cultivated Pepper

Seong Chan Lee, 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 고추 재배기간인 2022년 5월부터 9월까지 전북 고창, 충남 청양, 충북 괴산지역 고추 포장에서 2주 간격으로 황색끈끈이트랩을 이용하여 주요 해충 발생현황을 조사하였다. 주로 총채벌레, 담배나방, 진딧물이 발생하였으며 담배나방은 주로 7월 하순, 8월 상순~중순, 9월 상순에 밀도가 높았다. 총채벌레는 6월 상순부터 증가하기 시작하여 7월 중순에 밀도가 가장 높았다. 시기별로 총채벌레를 채집하여 동정한 결과 꽃노랑총채벌레, 대만총채벌레, 파총채벌레의 발생이 확인되었고, 이들 3종 중 대만총채벌레가 시기별로 가장 발생 밀도가 높았다. 방제를 위해 노지 고추에서 총채벌레는 6월 상순 이전부터 모니터링하고, 담배나방은 연 4회에 걸쳐 살충제를 살포하는 방제전략을 수립하는 것이 좋을 것으로 판단된다.

검색어: 노지, 고추, 총채벌레, 담배나방, 발생

P268

Effect of a commercial clove essential oils against the green peach aphid *Myzus persicae* Sulzer (Homoptera: Aphidiae)

Young Cheol Kim[1], Duck-Soo Choi[2] , Do-Ik Kim[2] and Song Hee Han[3]
[1]Department of Applied Biology, Chonnam National University
[2]Environment-Friendly Agricultural Research Institute, Jeollanamdo Agricultural Research and Extension Services
[3]HyunNong Co. LTD

Green peach aphid is an insect that causes significant economic losses in crops. The plant-based biopesticides is a promising environment friendly insecticide as an alternative for chemical insecticide. In this study, we evaluated efficacy of commercial clove essential oil (EO) against green peach aphid for their aphicidal activity under lab conditions. ODS-HPLC analysis of clove EO showed that eugenol (6.1 ± 0.1 g/100ml) was a major compound. The lethal concentrations and times (LC and LT) of the clove EO at different concentrations (1:50, 1:100 and 1:200) were determined on 3rd and 4th nymphal instars after exposure to different concentrations at different times. The clove EO exhibited strong aphicidal activity against the nymphs of the green peach aphid with median lethal concentration (LC50) of 262.0 ppm at 24 h exposure, and medial lethal time (LT50) of 1.6 h at 250 ppm exposure. Our results indicated the clove essential oil as promising insecticide and may be used effectively in the management of aphids as alternative tool to provide environment friendly approach.

Key words: clove oil, eugenol, essential oil, green peach aphid

P269

Developing eco-friendly management methods for the fall armyworm, *Spodoptera frugiperda*

Phuong Thi Nguyen[1], Nguyen Mihn Anh Hoang[2], A-Young Kim[1] and Young Ho Koh[1,2]
[1]ILsong Institute of Life Science, Hallym University, Seoul, Korea
[2]Department of Bio-medical Geronology, Hallym University, Chooncheon, Korea

The fall armyworm (FAW, *Spodoptera frugiperda*) is an invasive insect pest that migrates from Southeast Asia and southern China. FAW has a wide host range, causing great damage to various crops. From the end of May to July, the FAW adults flew to Korea, lays eggs, and reproduce, causing serious damage. Although there are crop protection agents approved for the control of FAW, no eco-friendly management technology has been developed so far. In this study, we developed eco-friendly control technologies that can be used to control the FAW. The technologies presented in this study will help develop methods to avoid developing drug resistance induced by repeated application of crop protection agents (Grant No.J014845032022).

Key words: fall armyworm, migratory pest, crop protectin, eco-friendly

P270

Investigation of phosphine resistance of stored-product insects of collection by Rice Processing Complex(RPC) in Korea during 2021 to 2022

Ji-eun Choi, Jun-ran Kim, Bong-su Kim and Young-mi Moon
Animal and Plant Quarantine Agency, Republic of Korea

Recently, the occurrence of phosphine resistant pests is increasing as the use of aluminium phosphide continues to increase due to the prohibition of the use of methyl bromide. In this study, phosphine resistance to pests collected from RPC in Korea during 2021 to 2022 was investigated. Phosphine resistance was investigated with FAO No. 16, Dihydrolipomaide dehydrogenase(DLD), and aminoacid mutation analysis. The pests collected in the 8 province 32 region were 2 order 12 family 22 species. As a result of the FAO test of 15 regions in which 200 insects were secured, all of them were sensitive, but the survival rate in Jincheon was high at 58.96%. As a result of the DLD test, some areas were moderate resistance. As a result of amino acid analysis, they were all sensitive. It is required to inspect the RPC and other grain storage continuously to inhibit the widespread of resistant pest.

Key words: Phosphine, Resistance, Rice processing complex, Fumigant

P271

Comparative efficacy of single and combined treatment of fumigants and low temperature to the green peach aphid, *Myzus persicae* (Sulzer)

Youn-sun Chang, Bong-su Kim, Young-mi Moon and Jun-Ran Kim
Animal and Plant Quarantine Agency, Republic of Korea

Aphids are one of the most important agricultural pest groups in the world. Some aphids can be a problem when importing or exporting agricultural product to other countries, so developing the proper fumigation method is important. In this study, we assessed the efficacy of single and combined treatment of quarantine fumigants, methyl bromide, ethyl formate and phosphine, mixed with cold treatment to control green peach aphid, *Myzus persicae*. Methyl bromide was treated for 2h and ethyl formate was treated for 4h at 20°C and phosphane treated for 2h, followed by 3 days cold (1°C) treatment. Combined treatment of fumigants and cold treatment showed less efficacy on *Myzus persicae* single treatment at low dosage, but efficacy was increased at higher dosage. The synergistic effect of combined treatment of chemical and physical treatment can be differed by pest species and treatment conditions.

Key words: *Myzus persicae*, phospine, ethyl formate, methyl bromide, low temperature treatment

P272

Phytotoxicity evaluation of two seedlings (*Aralia elata*, *Echeveria metallica*) treated with ethyl formate fumigant

Jinsung Yoo, Bong-su Kim and Jun-Ran Kim*
Animal and Plant Quarantine Agency, Republic of Korea

The cumulative number of regulated pests detected in seedlings over the past 10 years is 7,688, and the number of pests is steadily increasing. To control pests, disinfection using a fumigant was performed based on the disinfection treatment standards of the Quarantine Headquarters, but the damage caused by phytotoxicity during this disinfection process is rapidly increasing. In this study, ethyl formate fumigant was treated on *Aralia elata* and *Echeveria metallica* seedlings, which show phytotoxicity among imported seedlings, and then the degree of damage was observed. For EF, 10, 35, and 50 mg/L were treated for 4 hours, and in the case of *A. elata* after 3 days of treatment, fallen leaves occurred in all treatment groups. Afterwards, new leaves and stems grew, but the stems grew in an abnormal position, resulting in poor marketability. In the case of *E. metallica*, a visual inspection was conducted, and it was confirmed that the degree of phytotoxicity increased as the concentration of the fumigant increased. Since the treatment of fumigant according to the current disinfection treatment standard is a concentration that can cause phytotoxicity, it is necessary to review the treatment standard again for the treatment of the fumigant alone.

Key words: Ethyl formate, phytotoxicity, plant quarantine, disinfection treatment standards

P273

Individual treatment and complex treatment for phosphine, ethyl formate, and low temperature treatment for *Planococcus citri*

Jae-Ho Ban, Bong-su Kim, Young-Mi Moon and Jun-Ran Kim
Animal and Plant Quarantine Agency, Gimcheon 39660, Republic of Korea

Methyl bromide is a fumigant designated as an ozone-depleting substance, and several alternative fumigants have been used since methyl bromide was designated as an ozone-depleting substance. Phosphine and ethyl formate are used as alternative fumigants for methyl bromide. Among them, phosphine has the disadvantage that it needs to be treated for a long time, and ethyl formate has the disadvantage that it may cause phytotoxicity at high concentration, but these disadvantages can offset the shortcomings when both fumigants are treated together. In this study, phosphine, ethyl formate, and 5°C low-temperature treatment were performed on *Planococcus citri*, respectively, and they were treated together. As a result of the experiment, eggs showed the highest resistance to each fumigant, but showed the highest sensitivity to temperature treatment at 5°C. The nymphs showed the lowest resistance at fumigation treatment and 5°C temperature treatment, and the adults showed the highest resistance at 5°C. The best effect was achieved when both low-temperature treatment and both fumigants were combined in all stages.

Key words: Phosphine, Ethyl formate, Methyl bromide, Fumigation, *Planococcus citri*

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Screening test of Chinese herbal medicines for *Varroa* mites controlling

Yong Soo Choi[1], Dong Won Kim[1] and Eun Jin Kang[1], Pingli Dai[2], Jing Gao[2], Tong Wu[2], Qingyun Diao[2], Bo Han[2], Yin Lu[2], Pinghong Wang[2] and Li Zhang[2]

[1]Department of Agricultural Biology, National Institute of Agricultural Science, RDA, Wan-ju 55365, Republic of Korea

[2]Institute of Apicultural Research, Chinese Academy of Agricultural Sciences, Beijing, China

The *varroa* mite is major pest to *Apis mellifera*, Normally, many beekeepers was used chemical insecticidal materials for controlling number of *varroa* mite. Resently, many varroa mites were get resistance of chemical insecticidal materials. We want development of natural insecticidal materials to control of varroa mite by Chinese herbal medicines. At 48 h and 72 h, the corrected mites drop rates of the groups exposed to *Melia azedarach* L., *Foeniculum vulgare* Mill., *Eugenia caryophyllata* Thunb., *Thymus serpyllum* L. and *Macleaya cordata*(Willd.) R. Br. were about 40% higher than that of negative control group. In contrast, groups exposed to *Stemona japonica* (Bl.) Miq., *Strychnos nux-vomica* L., *Mentha haplocalyx* Briq. and *Illicium verum* Hook.f. had a lower mite drop rates. The survival rate of honeybees exposed *Thymus serpyllum* L. ($P < 0.0001$) and *Macleaya cordata*(Willd.) R. Br ($P = 0.0004$) was significantly lower than that of negative control. However, there is no significant difference in survival rate was observed between the honeybees exposed other seven herbs and negative control.

Key words: *Apis mellifera*; *Varroa* mite; *Thymus serpyllum* L.; *Macleaya cordata*

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Effect of natural enemy application model using ecological engineering technique in smart farm strawberry

Mihye Kim[1], Mijeong Kim[1], Jangwoo Park[1], Eunhye Ham[1] and Hyejeong Jun[2]

[1]Institute for Bioresources, Osangkinsect Co., Ltd.

[2]Department of Research Planning, National Institute of Ecology.

생태공학적 접근을 통한 농업생태계 다양성 유지로 생물 저항성을 극대화하는 지속가능한 작물 보호 체계 수립의 필요성이 증대되고 있다. 이에 본 연구에서는 스마트팜형 시설 딸기에 'Natural Enemy in First' (NEF) 기법과 약제를 혼합 적용하여 주요해충의 밀도에 미치는 영향을 확인하였다. 대조구는 친환경자재를 처리하여 비교하였다. 스마트팜형 시설 딸기 4개소에서 발생한 해충의 밀도는 잎응애류, 총채벌레류, 진딧물류와 가루이류 순으로 높게 확인되었다. NEF 처리구에서 총채벌레와 진딧물의 천적으로 참멋애꽃노린재(+*Portulaca* sp.)를, 잎응애류의 천적으로 칠레이리응애를 적용하여 해충의 밀도를 효과적으로 관리하였다. 특히, 1개소에서는 잎응애류 잎당 밀도가 대조구의 25% 수준으로 낮게 유지되었다.

검색어: 딸기, 서식처, 스마트팜, 천적, Natural Enemy in First (NEF)

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The effect of UV-LED lighting on *Phyllocnistis citrella* in Citrus

Changhak Oh[1], Dong-soon Kim[1], Untaek Lim[2], Younggyun Park[2], Hyejeong Jun[3] and Eunhye Ham[4]
[1]College of Applied Life Science, SARI, Jeju National University.
[2]Department of Plant Medicals, Andong National University.
[3]Department of Research Planning, National Institute of Ecology.
[4]Institute for Bioresources, Osangkinsect Co., Ltd.

지속가능한 해충관리를 위해 최첨단 혁신기술과 융합된 새로운 방제전략 수립이 중요해지고 있다. 이에 본 연구에서는 UV-LED 광원을 이용한 시설 감귤 해충관리 기술을 구축하고자 385nm LED 광원이 귤굴나방 밀도에 미치는 영향을 확인하였다. UV-LED 광원 설치 3개월 후, 감귤 잎의 귤굴나방 피해율은 무처리구의 57.8% 수준으로 낮게 유지되었다. 또한, 새순에 90% 수준으로 귤굴나방 피해를 유발한 후 UV-LED 광원을 설치한 처리구의 천적 발생률(기생률)은 무처리구의 1.97배 수준으로 높게 확인되었다. UV-LED 광원과 더불어 귤굴나방 밀도억제에 효과적인 약제와 천적이 혼합 적용된다면, 시설 감귤에서 귤굴나방의 밀도를 안정적으로 관리할 수 있을 것이다.

검색어: 감귤, 귤굴나방, 천적, 해충관리, UV-LED 광원

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CLIMEX modeling for predicting domestic spatial distribution of *Cicadella viridis*

Jae-Woo Song[1] and Wang-Hee Lee[1,2]
[1]Department of Biosystems Machinery Engineering, Chungnam National University, Daejeon, 34134, Korea
[2]Department of Smart Agriculture Systems, Chungnam National University, Daejeon, 34134, Korea

Cicadella viridis is a crop pest distributed in Europe and Asia. This pest is also a vector of *Xylella fastidiosa* that causes a severe damage to fruits. In this study, the potential distribution of *C. viridis* was domestically predicted by developing a CLIMEX model. Parameters were estimated based on climatic condition of *C. viridis* habitats, and optimal parameter values were finally determined by adjusting parameter values until the best fit to actual distribution was shown. The developed model was simulated under the current climate and future climate change scenario of 2050 (SSP245, and SSP585). As a result, high climatic suitability was predicted throughout the country, consistent with the current actual distribution of the pest. In 2050, a slight decrease in climate suitability was expected compared to the present, but the difference was not significant.

Key words: climate change, CLIMEX, green leafhopper, species distribution modeling, spatial distribution

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Analysis that thrips dominant species and test of pesticide resistant in occur of horticultural crops in Gangwon province

Heon-Seop Won, Kyung-Rin Bang, Gwang-Jae Lee, Jae-Hong Lee, Seung-Jae Lee, Sun-Joo Lee, Eun-Hye Kil, Seung-Min Ham, Sun-Ok Jo, Sung Hee Kang and Jae-Young Ko
Division of Agricultural Environment Research, Gangwon-do Agricultural Research and Extension Services. Chuncheon 24203, Korea

총채벌레(Thrips)는 토마토, 파프리카, 고추 등 주요 원예작물에 토마토반점위조바이러스(*Tomato Spotted Wilt Virus*) 감염이나, 과실기형을 유발하는 대표적인 바이러스 매개충이다. 이러한 총채벌레를 방제하기 위해서는 트랩 예찰을 통해 초기 발생 시 살충제를 살포하는 것이 가장 효과적인 방법이다. 하지만 동일약제 연용으로 인해 일부 품목에서는 저항성이 발생하고 있고, 종에 따라 처리약제에 대한 저항성이 각각 다르게 나타나기도 한다. 따라서 지역별 총채벌레 우점종 분석과 약제저항성 검정을 통해 효과적인 방제전략을 수립하기 위해 본 연구를 수행하였다. 총채벌레 우점종 분석은 도내 토마토, 파프리카 주요 재배지역인 춘천, 횡성, 평창, 철원의 주요 재배지점을 선정하여 작목에 발생한 총채벌레에 대해 종별 특이 프라이머를 활용한 PCR 분석으로 우점종 분석을 실시하였다. 그 결과 춘천 토마토에서는 대만총채벌레, 평창 파프리카는 꽃노랑총채벌레가 동정되었다. 횡성 파프리카 우점종은 꽃노랑총채벌레 였으며, 철원 파프리카는 꽃노랑 및 대만 총채벌레가 혼재하고 있었다. 이렇게 분석한 우점종 중 횡성 파프리카 꽃노랑총채벌레에 대해 약제 저항성 검정을 수행하였다. 시험약제는 전년도 농가 방제력 조사 시 지역별로 가장 많이 사용한 약제 3종과 대조구로 약제서항성이 있는 네오니코티노이드계통 2종을 선발하였다. 그 결과 네오니코티노이드 계통의 2약제는 방제가가 80%인 반면 시험약제 3종은 90% 이상의 방제가를 보여 실제로 약제 저항성이 있음을 확인하였다.

검색어: 총채벌레, 우점종, 대만총채벌레, 꽃노랑총채벌레, 약제 저항성, 네오니코티노이드

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Efficacy of commercial insecticides against Korean local populations of *Bemisia tabici*

In-hong Jeong, Gwan-seok Lee, Ye-yeon Gwak, Myung-Ju Kim, Kyung-hee Son and Jeong-Hwa Lee
Crop protection Division, National Institute of Agricultural Sciences, RDA

2021년 6월부터 10월까지 경기도 광주시 등 전국 12개 지역의 시설 및 노지 채소재배지에서 채집한 담배가루이 지역집단에 대하여 etofenprox EC 등 12개 시판 약제들에 대하여 추천농도와 그 1/10, 1/100농도에서 약제 반응을 엽침지법으로 조사하고 지역별 약제별 살충효과를 비교하였다. Thiamethoxam WG (7지역), Pyriproxifen EC (6지역), Etofenprox EC (5지역), Pyridaben EC (2지역)들은 추천농도(RC)에서 70%미만의 살충력을 보여 저항성이 의심되는 약제들이었으며, 특히 창녕, 삼례, 안성, 논산, 순천, 경기도 광주지역에서 이들 약제에 대한 사용상에 주의가 필요할 것으로 판단되엇다. 반면에, emamectin benzoate EC, flupyradifurone SL, spinetoram SC, pyrifluquinazone WG는 대부분의 지역에서 추천농도의 1/10농도 (0.1RC)에서도 70%이상의 살충력을 보여주어 국내에서 담배가루이 방제용으로 효과가 우수하였다.

검색어 : 담배가루이, 살충제 약제반응, 지역계통, 한국, 중국

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Insecticidal activity of Fluxametamide against FAW

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

Fall armyworm(FAW) has been a problem worldwide since its first outbreak in Africa in 2016. It also found in Korea by wind through China. Faw is euryphagous pest that harms about 80 kinds of crops. One female lays more than 1000 eggs at a time, so It is best to control it in a quick and correct way. Fluxametamide is an isoxazol based in insecticide that blocks the transfer of GABA(Gamma-aminobutyric acid), disturbs nerves, and kills pests. It has high insecticidal effect on a wide range of pests, such as Lepidoptera, Thysanoptera, Hemiptera. In order to find out the bioactivity of Fluxametamide, dipping and spraying methods were compared for the FAW L3 and L5. The result of this study will be used as basic data to control methods for overseas pests that can occur in large numbers.

Key words: Fall armyworm, Fluxametamide, GABA recepter, Insecticidal activity

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Repellency effects of *Perilla frutescens* supercritical fluid extract against *Hamaphysalis Longicornis*

Yu Seon Noh, Ji Yun Byeon, Yun Chang Jang and Young Su Jang
Nano Bio Reaserch Center, Jeonnam Bioindustry Foundation, Jangseong, 57248, Republic of Korea

Supercritical fluid extraction (SFE) is a rapid, selective and convenient method for sample preparation prior to the analysis of compounds in the volatile product of plant matrices. The hard tick, *Haemaphysalis longicornis.*, which is widely distributedin East Asia and Oceania can act as a vector for viruses, chlamydia, rickettsia, bacteria, and protozoa. The repellencies of *P. frutescens* extract was evaluated in comparison with the two commercial repellency (Icaridin and DEET) against *H. longicornis*. In filter-paper diffusion method, *P. frutescens* extract (3.2 μg/cm^2) gave 100% repellency at 120 min after exposure. Whereas Icaridine (3.2 μg/cm^2) gave 96.1 % repellency, respectively, at 120 min. The repellency of the Peillaldehyde against *H. longicornis* was compared with that of DEET at 3.2 mg/cm^2. Responses varied according to the test compound and exposure time. Peillaldehyde gave 100% repellency 30 min post-treatment but 75.1% repellency at 120 min, respectively. *P. frutescens* extract and Peillaldehyde described merit further study as potential fumigants or leads for the control of *H. longicornis*.

Key words: Supercritical fluid extraction, *Haemaphysalis longicornis*, *Perilla frutescens,* Peillaldehyde

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Repellency effects of *Chamaecyparis obtusa* supercritical fluid extract against *Hamaphysalis Longicornis*

Ji Eun Lee, Sung Hwa Oh, Yu Seon Noh and Young Su Jang
Nano Bio Reaserch Center, Jeonnam Bioindustry Foundation, Jangseong, 57248, Republic of Korea

Supercritical fluid extraction (SFE) is a rapid, selective and convenient method for sample preparation prior to the analysis of compounds in the volatile product of plant matrices. The hard tick, *Haemaphysalis longicornis.*, which is widely distributedin East Asia and Oceania can act as a vector for viruses, chlamydia, rickettsia, bacteria, and protozoa. The repellencies of *C. obtusa* oil was evaluated in comparison with the two commercial repellency (Icaridin and DEET) against *H. longicornis*. In filter-paper diffusion method, *C. obtusa* oil (3.2 μg/cm^2) gave 100% repellency at 120 min after exposure. Whereas Icaridine (3.2 μg/cm^2) gave 96.1 % repellency, respectively, at 120 min. The repellency of the 31 compounds against *H. longicornis* was compared with that of DEET at 3.2 mg/cm^2. Responses varied according to the test compound and exposure time. α-Terpinene, terpinene-4-ol and α-terpineol gave 100% repellency 30 min post-treatment but 85.5, 56.4 and 68.9% repellency at 120 min, respectively. α-Pinene and β-pinene gave 97.6 and 89.5 % repellency at 10 min, post-treatment but 67.4 and 0 % repellency at 120 min respectively. Limonene, γ -terpinene, terpinolene and terpinyl acetate gave 50% repellency at 30 min but repellency of these compounds was significantly low at 30 min. *C. obtusa* oil and α-terpinene, terpinene-4-ol and α-terpineol described merit further study as potential fumigants or leads for the control of *H. longicornis*.

Key words: Supercritical fluid extraction, *Chamaecyparis obtusa*, *Haemaphysalis longicornis*

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Analysis of attraction effect by pheromone product and height of fall armyworm, *Spodoptera frugiperda*

Nak Jung Choi, Bo Yoon Seo, You Kyoung Lee, Sang-Min Kim, Soo Yeon Choi, Hyunjung Chung, Tae Hwan Noh and June-Yeol Choi
Crop Foundation Division, National Institute of Crop Science

아메리카 대륙이 원산지인 열대거세미나방은 2019년 제주도에서 최초 발견 후 전국 50.6㏊(2019년 기준)에서 발생이 확인되었다. 최근 옥수수, 수수 등 잡곡의 수요 증가로 기주 작물 재배가 증가하여 전국적으로 피해가 발생하고 있으므로 열대거세미나방에 의한 피해를 예방하기 위해 효율적인 예찰법 개발이 필요한 상황이다. 이를 위해 국내외 시판 중인 성페로몬 제품 5종(미국산, 중국산, 네덜란드산, 코스타리카산, 한국산)별, 트랩 설치 높이별 성충 유인효과와 안테나 반응 분석을 실시하였다. 트랩은 펀넬트랩을 이용하였으며, 2020년 7월부터 10월까지 조사하여 페로몬 종류에 따른 성충 유인량을 비교하였다. 총 포획수는 미국산(609마리) > 코스타리카산 > 중국산 > 네덜란드산 > 한국산의 순이었다. 트랩 설치 높이는 10㎝, 80㎝, 100㎝, 120㎝, 140㎝에 설치하여 유인수를 비교한 결과 10㎝를 제외하고 높이별로 차이는 거의 없으나 120㎝에서 가장 많은 수의 성충이 포획되었다. 페로몬 제품에 따른 안테나 반응은 페로몬별로 유의한 차이는 없지만 미국산에서 반응이 가장 민감한 것으로 나타났다. 열대거세미나방의 효과적인 예찰을 위한 추가적인 연구가 필요한 것으로 사료된다.

검색어: 열대거세미나방, 페로몬 트랩, 루어, 예찰

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Investigation of occurrence of insect foreign materials claims in some kinds of processed food

Jahyun Na1[1], Jungmin Kim[2], Sang Hun Yeo[3] and Taekyong Moon[4]
[1]Institute of Life Science and Natural Resources, Korea University
[2]Functional Food Research Center, Korea University
[3]HIPOS R&C Research Institute, [4]Nam Kyung Co., Ltd.

가공식품에서 발생하는 곤충이물 소비자 클레임을 저감화하는 허들방충포장을 개발하기 위해 곤충이물 발생빈도가 높은 가공식품(과자류, 봉지면류, 용기면)에서 2018년부터 2021년까지 최근 발생된 곤충이물 클레임 529건을 신고당시 소비자 증언, 클레임 발생 현물, 사진 등의 자료를 기반으로 분류학적 곤충 종, 생태학적 특성, 발생유형, 오염경로를 분석하였다. 분류학적으로 과자류에서는 파리목, 봉지면류에서는 나비목, 용기면류에서는 딱정벌레목의 빈도가 가장 높았으며 생태학적으로 모든 식품유형에서 야외해충이 가장 높은 빈도를 보였다. 발생유형은 모든 식품유형에서 치사성충 유형의 빈도가 높았으며 오염경로는 유통, 소비 단계에서 대부분 오염되는 것으로 조사되었다.

검색어: 허들방충포장, 가공식품, 소비자클레임, 곤충이물, 저장해충

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Annual distribution and abundance of stored product insects in korean wheat general storage facility

Jahyun Na[2], Hyeok Kwon[2] and Wook Kim[1]
[1]Department of Biosystems and Biotechnology, Korea University
[2]Institute of Life Science and Natural Resources, Korea University

본 연구는 2025년 까지 우리 밀 자급률 5%를 달성하기 위한 밀산업 육성법의 일환으로 우리 밀 수확 후 비축 시 친환경 저장해충 방제 방법을 도출하기 위해 진행되었다. 1단계 연구로 현재 대부분 쌀, 보리, 밀을 수확 시기별로 톤 백 상태로 상온에서 혼합 보관하는 소규모 유통, 보관 시설과 밀을 수확, 건조 후 보관하는 톤 백 내부에서 연간 저장해충 발생양상을 조사하기 위해 부여의 영농조합 시설과 시설 내 보관 중인 톤 백 내부에서 페로몬 트랩과 probe 트랩, 자동온습도측정기를 활용하여 저장발생 해충양상과 온습도를 모니터링 하였다. 톤 백 내부에서의 저장해충 발생양상은 수확 후 보관 초기에 머리대장류, 곡식쑤시기의 포획수가 높았으나 시간이 지남에 따라 어리쌀바구미의 포획수가 증가하는 경향을 보였으며 보관 후 1년경과 시점에서 화랑곡나방의 개체수가 급격히 증가하여 톤 백 내부가 화랑곡나방 유충 실크로 거의 대부분 오염되는 양상을 보였다.

검색어: 우리 밀, 톤 백, 저장해충, 모니터링, 페로몬 트랩, Probe 트랩

P286

Heavy metal reduction test for *Protaetia brevitarsis* larvae as edible insects using effective microorganisms

Kyu-Won Kwak, Eunsun Kim and Yong-Soon Kim
Department of Agricultural Biology, National Institute of Agricultural Sciences, South Korea

Recently, as the scope of heavy metal management of edible insects has been expanded in Korea and the integrated standard for edible insect heavy metals has been needed. *Bacillus subtilis, Bacillus subtilis*, *Lactobacillus plantarum*, and *Saccharomyces cerevisiae* microbial mixture culture (BLS: diluted solution of concentration 5^{-1}, 2.5^{-1}, etc.) and weight, feces, and heavy metal content of *P. brevitarsis* larvae were measured. In the BLS-treated group, lead was detected 30 times lower, cadmium 11.7-35 times, and arsenic 1.8-3.5 times lower compared to control group, confirming that the larval heavy metal reduction efficacy was increased. In the experimental groups fed from egg stage, the arsenic content was lower than in the experimental group fed from the second instar larvae. On the other hand, in the fecal soil and food sources, the lowest levels of lead 0.1, cadmium 0.0, and arsenic 0.0 mg/kg were detected in the 2.5^{-1} dilution. Therefore, it was confirmed that the effective microorganisms were shown in the *P. brevitarsis* growth characteristics and heavy metal reduction efficacy.

Key words: heavy metal reduction, *Protaetia brevitarsis*, edible insects, effective microorganisms

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A study on entomopathogenic nematode symbiotic bacteria in Korea

Namjun Chung[1], Seongmo Koo[1], Youngjoon Kim[1], Geungon Kim[1], Dajeong Son[2], Youngmoo Choo[2], Yeojin Kim[3] and Gilsang Jeong[3]

[1]Division of Research and Development, Nambo Co., Ltd.
[2]Jinju Bioindustry Foundation
[3]National Institute of Ecology

Entomopathogenic nematodes (*Heterorhabditis megidis, Steinernema carpocapsae, S. arenarium, S. monticolum*), which are pathogenic to bait insect *Galleria mellonella* larvae, were isolated and identified from soil samples collected from oak (*Quercus* sp.) and Japanese larch (*Larix kaempferi*) habitat across Korea. From the entomopathogenic symbiotic bacteria, the genomic DNA was isolated, and the amplification of the 16s rRNA region was performed to analyze the nucleic sequence and homology. Symbiotic bacteria of *H. megidis* isolated from the oak habitat soil samples were identified as *Photorhabdus temperata*. The bacterial symbiont of *H. megidis* isolated from soil samples of Japanese larch habitat was identified as *P. cinerea*. In addition, symbiotic bacteria isolated from *S. carpocapsae, S. arenarium, S. monticolum* of Japanese larch habitat soil samples were identfied as *Xenorhabdus nematophila, X. kozodoii, X. hominickii* respectively. The number of entomopathogeic gene types of bacterial symbionts *P. temperata, P. cinerea, X. nematophila, X. kozodoii, X. hominickii* were turned out to be 8, 7, 10, 4, 7, respectively.

Key words: Oak, Japanese larch, Entomopathogenic nematode, Symbiotic bacteria, *Galleria mellonella*, *H. temperata*, *H. cinerea*, *S. carpocapsae*, *S. arenarium*, *S. monticolum*, *P. temperata*, *P. cinerea*, *X. nematophila*, *X. kozodoii*, *X. hominickii*

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Nutritional value of *Protaetia brevitarsis* larvae feeding a food source containing soybean curd cake

Sun Young Kim[1], Taeho Yoo[2], Sangmin Ji[1] and Jeong-Hun Song[1]
[1]Department of Agricultural Biology, National Institute of Agricultural Sciences, RDA
[2]Snowflower farm, Sejong

비지박을 급이한 흰점박이꽃무지 유충의 영양학적 우수성과 안전성을 검증하고자 비지박 함유 먹이원과 참나무 발효톱밥만으로 사육한 유충의 영양성분과 유해물질을 비교분석하였다. 조단백질 함량은 비지박 함유 먹이원을 급이한 유충(SCC)에서 50.0%로 참나무 발효톱밥으로 사육한 유충(CTR) 44.7%보다 1.1배 많았다. 조지방은 SCC에서 8.1%로 CTR 13.5%보다 1.7배 더 적었다. 불포화지방산 중 올레산 함량은 SCC(44.0%)에서 CTR(61.1%)보다 1.4배 더 적게 나타났으나, 리놀레산은 SCC(26.4%)에서 CTR(5.2%)보다 5.0배 많은 것으로 확인되었다. 다량무기질 중 가장 많은 함량을 나타낸 칼륨은 SCC(3169.6 mg/100 g)에서 CTR(1245.9 mg/100 g)보다 2.5배 더 많았다. 미량무기질 중 아연은 SCC(103.0 mg/100 g)에서 CTR(8.2 mg/100 g)보다 12.6배 높은 함량을 나타냈다. 유해물질 분석 결과, 납, 카드뮴, 비소 모두 식용곤충 중금속 기준에 적합하였고, 병원성 미생물인 대장균, 살모넬라균 모두 불검출되었다. 위의 분석 결과로 볼 때, 비지박을 급이한 흰점박이꽃무지 유충은 다양한 영양성분을 포함하고 있으며, 안전성 또한 검증되었으므로 식용으로 활용하기에 적합할 것으로 판단된다.

검색어: 흰점박이꽃무지, 유충, 비지박, 먹이원, 영양 가치

P289

Analysis of spreading pattern by time series prediction of pine wilt disease

Jae-Min Jung[1], Sunhee Yoon[2], Jinhyeong Hwang[3], Yuri Park[3] and Wang-Hee Lee[1]
[1]Department of Smart Agriculture Systems, Chungnam National University, Daejeon, 34134, Korea
[2]Department of Biosystems Machinery Engineering, Chungnam National University, Daejeon, 34134, Korea
[3]Division of Monitoring & Analysis, Forest Pests & Diseases Monitoring Headquarters, Korea Forestry Promotion Institute, Daejeon, 35209, Korea

Pine trees is one of the most important trees in South Korea, and many efforts are exerting to protect the trees. The damage to pine trees occurs in a variety of ways, but pine wilt disease (PWD) is the largest concern in these days. As an effective tool to protect pine trees from PWD, early monitoring of spread pattern has been emphasized. This study, hence, used monthly occurrence coordinates (2016—2021) to extract the time series pattern of PWD, and applied species distribution modeling (MaxEnt) to project the monthly potential distribution on the map. The maximum and minimum accuracies were 0.84 and 0.76, respectively. There was a difference in the PWD occurrence by months, and the occurrence density was changed by time. We expect that the present results are applicable for PWD monitoring, and control in the future.

Key words: pine wilt disease, species distribution modeling, spread pattern, time series data

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Developmental and reproductive characteristics following low-temperature storage of *Protaetia brevitarsis seulensis* larvae

Sangmin Ji, Sun Young Kim and Jeong-Hun Song
Department of Agricultural Biology, National Institute of Agricultural Sciences

농산품의 출하 시기를 인위적으로 조절하기 위해 다양한 저장법이 개발되고 있다. 산업곤충 역시 장기저장을 통해 농장주가 원하는 시기에 맞춰 농산품을 생산할 필요성이 점차 커지고 있다. 그 중, 우리는 살아있는 흰점박이꽃무지 유충을 대상으로 저온 저장 방법을 연구하였다. 흰점박이꽃무지 3령 초기 유충을 온도별로(15, 12, 10, 7.5, 5℃) 먹이원의 유무에 따라 3개월간 저온 저장 후 18, 25, 30℃로 옮겨 4주간 매주 무게를 측정하였다. 무게는 비모수 검정법을 이용하여 비교하였다. 그 결과, 7.5℃ 이하의 온도에서는 먹이원 유무와 관계없이 유충이 모두 사망하였고, 10℃ 이상의 온도에서는 먹이원이 없을 때 모두 사망하였다. 최적의 저장온도는 12℃로서 12℃ 저온처리 후 30℃로 옮겨 사육하였을 때 유충의 증체율과 유충 시기 최대 무게가 높게 나타났다($p<0.05$). 추가로 최적 저장온도(12℃)에서 저장기간에 따른 발육특성을 비교하였다. 3령 초기 유충을 12℃에서 2, 4, 6, 8주간 저장 후 유충과 번데기 기간, 최대 무게 도달 기간 그리고 산란율을 비교하였다. 생육특성은 ANOVA 검정을 통해 비교하였다. 그 결과, 8주간 저온 저장 시 유충 기간이 가장 짧았다(39.26일, $p<0.05$). 유충의 최대 무게는 통계적으로 차이가 나타나지 않았다. 산란율은 저온처리 기간이 길수록 증가하는 경향을 보였다. 이 결과를 통해 12℃에서 3개월 이내로 저온 저장하여 출하 시기를 조절할 수 있고, 저온처리를 8주 이상 처리하여 산란율을 증대할 것으로 기대한다.

검색어: *Protaetia brevitarsis seulensis*, 발육특성, 저온 저장

P291

Effects of the healing agriculture program for elderly using the silkworm *Bombyx mori* (Linnaeus)

Mi-Seon Song, So-Yun Kim, Jeong-Hun Song and Sangmin Ji
Department of Agricultural Biology, National Institute of Agricultural Sciences

대한민국은 초고령사회에 접어들었다. 수명이 증가하는 것에 비해 노인들의 경제활동과 보살핌은 부족한 상황이라서 사회적 불안감과 우울감이 증가하는 추세이다. 본 연구는 농촌마을의 노인들을 대상으로'누에나방[*Bombyx mori* (Linnaeus)]'을 이용하여 개발한 치유농업프로그램을 현장에 적용하고 효과를 측정하였다. 2022년 5월, 전북 고창군의 경로당을 이용하는 노인 20명이 대상자이며, 당일 프로그램으로 운영되었다. 누에나방은 나비목의 곤충으로 70~80년대 집집마다 누에를 키웠던 경험을 회상시켜주기 때문에 선호도가 높다는 장점이 있다. 주요 프로그램으로 애벌레 만져보기, 뽕잎 먹는 소리 듣기, 고치 잘라보기 등의 활동으로 구성하였다. 치유효과 검증을 위해 자기 기입식 설문지를 작성하였고 혈압을 측정하였다. 분석 결과, 사전 대비 사후에 스트레스는 25% 감소하였고, 수축기 혈압은 135.55→131.50(mmHg)으로 감소하였다($p<0.05$). 프로그램에 대한 만족도는 100점 만점에 95.3점으로 나타났다. 이러한 결과 누에를 이용한 치유농업프로그램이 노인의 스트레스 감소와 혈압을 안정화 시키는데 효과가 있음을 확인한 것으로, 향후 보다 체계적인 프로그램으로 적극 활용될 수 있을 것으로 기대한다.

검색어: 정서곤충, 누에나방, 치유농업프로그램, 치유효과

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Development and effectiveness of farm model insect healing program for developmental disorders

Hyunmyung Choi, So-Yun Kim, Jeong-Hun Song and Sangmin Ji
Department of Agricultural Biology, National Institute of Agricultural Sciences

2022년 1월 기준으로 전국에 등록된 발달장애인의 수는 255,207명이다. 이들은 사회 진출, 여가 생활, 경제활동 등의 기회가 적을 뿐 아니라 복지, 여가 프로그램도 매우 부족한 것이 현실이다. 이에 정서곤충을 활용한 농가형 곤충치유프로그램을 개발하여 현장에 적용하고 그 효과를 구명해 보았다. 전북 순창군의 치유농가에서 발달장애인 18명의 성인을 대상으로, 2022년 6월-8월간 매주 1회, 총 10회차 프로그램을 운영하였다. 주요 프로그램은 정서곤충(호랑나비, 왕귀뚜라미)을 돌보는 활동을 중심으로 먹이 식물 심기, 은신처 만들기, 곤충 캐릭터 부채 만들기 등이며, 특히 농가에서 보유하고 있는 자원을 활용한 프로그램인 '귀뚜라미 소리를 들으며 족욕 하기'와 '나비 모양 샌드위치 만들기' 등은 참여도가 높았다. 치유 효과 측정을 위해 심리 및 생리적 검사를 시행했으며, 분석 결과, 사전 대비 사후에 수축기 혈압은 138.3→127.9(mmHg)로 낮아졌고, 이완기 혈압은 83.9→80.2(mmHg)로 감소하였으며, 주관적 행복감은 18% 증가한 것으로 나타났다($p<0.05$). 이를 통해 발달장애인을 대상으로 한 곤충치유프로그램의 가능성을 확인할 수 있었다.

검색어: 정서곤충, 발달장애인, 치유프로그램, 치유효과

P293

Comparison of Growth on *Papilio xuthus* according to host plant preservation methods

Youngmi Kim, Youngmin No, Changmin Ahn, Eunsun Keum, Sujung Yun and Kyunghwa Seo
Silkworm and Insect Management Center Agricultural Resource Management Institute
Gyeongbuk Provincial Government 37110, Republic of Korea

The yellow swallowtail butterfly(*Papilio xuthus*) is holometabolous that undergoes different stages. Larvae change shape and color during the larval period. Adults has wings with black stripes on a yellow background, so they have been called tiger-butterfly since ancient times. Recently, there have been previous studies showing that psychological healing programs using *Papilio xuthus* increase children's feelings of happiness and help relieve stress.

The Gyeongbuk Provincial Silkworm and Insect Management Center has been producing *Papilio xuthus* rearing kit for ecological experience education. But production was stopped since 2019 due to difficulties in host plant. In order to solve the problem, The host plant changed to *Phellodendron amurense* with LDPE BAG. In this study, an experiment was conducted to compare the growth differences of *Papilio xuthus* according to host plant preservation methods in rearing kit. As for the experimental conditions, host plants were subdivided into LDPE BAG for 20 branches and 10 branches. As a result of the experiment, the survival rate from larvae to adults was 33.3% for control group, 26.7% for A group(20 branches), and 13.3% for B group(10 branches). The pupation rate was 60% for control group, 60% for A group, and 50% for B group. The emergence rate was 40% for control group, 30% for group A, and 40% for group B.

Key words: *Papilio xuthus*, host plant, preservation methods

This work was supported by a grant from RDA(No. PJ015738).

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Current status of pine wood nematode GeneBank in Korea

Heejung Kim, Youngho Kim, Heonil Kang, Chansik Jung and Hyerim Han
Division of Forest Entomology & Pathology, National Institute of Forest Science, 02455, Seoul, Korea

Pine wilt disease (PWD) is mainly caused by *Bursaphelenchus xylophilus* (Pine wood nematode, PWN) which is known to be native to North America. It was introduced from North America to Japan in the early 1900s and reported to occur in 1988 in Korea. Currently, PWD is occurring in about 390 thousand infected trees in 136 administrative districts in Korea. GeneBank of PWN in NIFoS has been operating since 2006 to collect and maintain 192 Korean populations. These populations are cultured on the fungus *Botrytis cinerea* grown on barley grains. The maintained populations are being used for establishing a species diagnosis, integrated management, and discovering useful genes related to population genetics, phylogenetic studies, and epidemiological investigation.

Key words: *Bursaphelenchus xylophilus*, Culture, GeneBank, Pine wilt disease, Population genetics

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Effect of black soldier fly larvae manure application on lettuce growth

Ju Hee Yu, Hyun Ju Kim, Young Uk Pack, Ji Su Lee, Young-Il Kim and Ki Su Ahn
Chungcheongbuk-do Agricultural Research & Extension Services

아메리카동애등에 유충은 유기성폐기물을 먹이원으로 하며 그 분해산물인 동애등에분은 비료원료로 활용 가능하다. 하지만 농가에서 나오는 동애등에분의 염분은 비료공정규격인 2%를 초과하여 배출된다. 따라서 염분을 낮추기 위해 동애등에분과 흰점박이꽃무지분을 비율별로 혼합하여 총 5개 처리구(무처리, 동애등에분:흰점박이꽃무지분 10:0, 7:3. 4:6, 가축분퇴비)를 청치마 상추에 시용하였다. 상추 생육은 7일 간격으로 엽장, 엽폭, 엽수를 조사하였고, 수량은 5주차부터 8주차까지 조사하였다. 처리구별 상추수량(kg/10a)은 무처리구 253.8kg, 동애등에분:흰점박이꽃무지분 10:0처리구 356.3kg, 7:3처리구 286.7kg, 4:6처리구 267.0kg, 가축분퇴비구 266.0kg으로 나타났으며 증수율은 무처리 대비 동애등에분:흰점박이꽃무지분 10:0처리구는 40.4%, 7:3처리구 13%, 4:6처리구 5.2%, 가축분퇴비구는 4.8% 증수하였다. 상추 생육은 동애등에분 단독 시용이 효과가 가장 좋았으나 장기적인 실험을 통해 토양과 작물에 미치는 영향을 모니터링해야 될 것으로 판단된다.

검색어: 동애등에분, 흰점박이꽃무지분, 상추생육, 상추수량

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Swine edema disease recombinant antigen production using silkworm

Chan Young Jeong, Jong Woo Park and Kee Young Kim
Department of Agricultural Biology, Rural Development Administration

Pig edema disease is a bacterial infectious disease that causes diarrhea and edema in piglets after weaning and leads to death. Pathogenic *E. coli*, which produces a toxin called shiga-toxin, infects and proliferates in the intestine of an animal, and sends the toxin into the blood vessel. The simplest method for preventing edema caused by these bacterial toxins is to obtain immunogenicity against the toxin antigen by injecting a vaccine.

Therefore, in this study, the production of recombinant antigens usable as vaccines was studied by making a recombinant insect virus and infecting the silkworm pupa. After synthesizing the genes of the B subunit, the cell binding site of shiga-toxin, and the A subunit, the toxin active site, the genes were cloned into the pFast-Bac vector. After the gloned vector was prepared in the form of Bac-mid, it was infected with insect cells to produce a recombinant virus, and the produced virus was again infected with the pupae of silkworm to produce a recombinant protein. As a result, each gene for the recombinant protein was observed from the 2nd day and was maximally expressed on the 5th day, and the protein expression was also maximized on the 5th day. The expressed protein was successfully isolated through pupae and extracts prepared by ammnonium sulfate fractionation method and NI-NTA chromatography. However, since the expression rate of the protein was low, the purification concentration was low, and in order to use it as a vaccine, it is judged that it is necessary to study a system that can express it at a high concentration.

Key words: Swine edema, silkworm, recombinant vaccine

P297

Growth effects of novel heating system using heater-installed rearing tray on silkworm, *Bombyx mori*

Chan Young Jeong, Kee Young Kim, Nam-Suk Kim, Sang Kuk Kang, Jong Woo Park, Ik Seob Cha and Seong-Wan Kim*
Sericultural and Apicultural Materials Division, RDA

Silkworms with high economic and industrial value are known to be easily damaged by environmental factors. It is very important to manage temperature and humidity for silkworm feeding facilities. In this study, the new rearing method that directly heats the bottom of the rearing tray was developed. The novel heater-installed tray (HIT) system significantly reduced the change in temperature during the experimental period. In addition, the number of days of silkworm growth up to harvest was shortened, and it was also found that silkworms grew more uniformly in HIT system than in previous system. In conclusion, the heater-installed rearing tray method greatly improves silkworm quality, increases weight of silkworms, and final profits compared to the previous room heating system with electric heaters.

Key words: *Bombyx mori*, Silkworm breeding seat, Heater-installed tray

P298

Psychological effects of healing program of insect with insect garden

Eunsun Keum, Youngmi Kim, Changmin Ahn, Sujung Yun and Kyunghwa Seo
Silkworm and Management Center Agricultural Resource Management Institute Gyeongbuk Provincial Government 37110, Republic of Korea

The study aims to examine the psychological effect of healing program of insect in ecological garden. A samples of 12 elementary students was participated for the study from near study area in Sangju. Students in the experimental group participated in healing program of insect-based experience activities using silkworm and butterfly. Collected data are transformed log(x+1) for analysis and analyzed with paired sample t-test in SAS program. The results of this study are healing program of insect-based experience activities show positive effects to some students in physiological aspects. And students and their parents showed high satisfaction in healing program of insect. In conclusion, this study contributes to providing fundamental information for the development of agro-healing programs with insect and insect ecological garden. Further research should be extended to different types of old adults and others.

Key words: Psychology, Insect, Silkworm, Agro-healing program, Ecology, Ecological psychology

This study was supported by a grant from the Rural Development Administration(RDA, PJ015738) of the Republic of Korea.

P299

The appropriate density of Bomblebee (*Bombus terrestris*) colonies in tomato greenhouse

Young Uk Park, Sun Kook Kim, Ji Su Lee, Hyeon Ju Kim, Ju Hee Yoo and Ki-Su Ahn
Chungcheongbuk-do Agricultural Research & Extension Services

시설채소의 평균 재배면적이 넓어지고 인건비의 증가 및 코로나19로 인하여 인력수급이 어려워지면서 화분매개곤충의 역할은 더욱 중요하게 되었다. 따라서 본 연구는 화분매개곤충인 서양뒤영벌을 방울토마토 단동하우스(550㎡) 재배시설에서 하우스별 1, 1.5, 2봉군까지 투입하여 수분활동 및 수확량 등을 조사하였다.

조숙재배(4~6월)시기 방울토마토에서 1봉군 투입 시 꽃 수량 증가가 상대적으로 높았으나, 봉군의 투입 밀도가 높을수록 수분활동이 높아 꽃 수량은 줄어드는 경향이었다. 착과율은 2봉군 투입시 96.4%로 가장 높게 나타났다. 수확 후 상품성 조사 결과 과립중은 2봉군에서 16.8g으로 가장 높았으나 당도는 1.5봉군에서 7.0Brix로 가장 높았다.

검색어: 시설토마토, 서양뒤영벌, 방화활동, 상품성

P300

Effects of a larval powder of steamed and lyophilized mature silkworms, *Bombyx mori*, L., on body weight gain and abdominal visceral fat in mice

Hyun-Tai Lee
Biopharmaceutical Engineering Major, Division of Applied Bioengineering, College of Engineering, Dong-eui University

In East Asia, silkworms, *Bombyx mori* L., have been traditionally used as an oriental medicine to manage diverse pathological conditions including obesity-related diseases such as hyperglycemia. Therefore, the present study was performed to determine the effects of daily administration of a larval powder of steamed and lyophilized mature silkworms (SMSP) on body weight change, abdominal visceral fat, and its safety for long-term use in mice. SMSP (1 g/kg) was orally administered to mice on a daily basis for 12 weeks, and the mice's body weights and food intakes were measured throughout the period. The treatment of SMSP for 12 weeks significantly reduced body weight gain and abdominal visceral fat. There were no significant differences between in control and SMSP treated groups for the serum biochemical parameters and organ weights at necropsy. Further studies are needed on SMSP in high-fat diet-induced obese mice to elucidate the mechanisms of suppressing body weight gain and abdominal visceral fat.

Key words: Abdominal visceral fat, body weight gain, *Bombyx mori*, mature silkworm, obesity

P301

Similar nutrients and health improvement effect of HongJams made from mature silkworm weaving yellow cocoons

Min Young Kim[1], Sang-Kuk Kang[2], Nam-Suk Kim[2], Kee-Young Kim[2] and Young Ho Koh[2]
[1]ILsong Institute of Life Science, Hallym University, Seoul, Korea
[2]Division of Agricultural Biology, National Institute of Agricultural Science, Wanju, Korea

HongJam is a natural health food made possible for human consumption by processing mature silkworms. For examples, HongJam produced with White Jade variety which made white cocoons has an excellent protective effect on the liver and gastrointestinal tracts while HongJam made from Golden Silk variety which made yellow cocoons were reported to have effects on Parkinson's disease inhibition, neuronal cell protective, memory enhancement, and Alzheimer's disease prevention. In this study, the nutritional components and functionality of the two HongJams produced from silkworm varieties made yellow cocoons were compared to investigate whether they could be replaced each other (Grant No. PJ0156592022).

Key words: HongJam, Golden Silk, Dae Hwang Jam, nutrients, memory

P302

Health promotion effect of HongJam through boosting immune responses

A-Young Kim[1], Hee-Jung Choi[2] and Young Ho Koh[1]
[1]Department of Zoology and Envionmental Sciences, Punjabi University, India
[2]School of Agricultural Biotechnology, Seoul National University

Hongjam is a health improvement functional food manufactured by steaming and freeze-drying mature silkworms. However, studies on the immune-enhancing effect of HongJam have not yet been HongJam. In this presentation, we present and discuss the results of research on the immunity-boosting effect of HongJam (Grant No. PJ0170242022).

Key words: HongJam, immune, health promotion, boosting

P303

Application and comparison of (AI) Artificial Intelligence approach for classification of cicada sounds

Kyung-Su Kim[1], Jisu Lee[1], Dong-seok Jang[2], Kyung-Min Park,[2] and Teawoo Kim[2]
[1]Coreit, Inc, Cheongju, Korea
[2]Department of Biological Resources Research, National institute of Biological Resources, Incheon 22689, South Korea

소리 분류 기술은 딥러닝을 통해 다양한 분야에서 활용되고 있다. 멀티미디어 생물정보 데이터를 활용하기 위해 인공지능 기술을 적용하고 성능을 테스트하였다. 7월~9월간 채집한 한국산 매미 12종의 울음소리와 기존에 채집된 데이터를 활용하여 소리 분류를 위한 전처리를 수행하였다. 매미 종별 소리 데이터는 소리 데이터를 1초 간격으로 분할하여 tensorflow 라이브러리를 활용하여 스펙트로그램 이미지로 변환하였고 합성곱신경망(CNN) 딥러닝 모델에 적용하여 자동 종 분류 시스템을 개발하였다. 특히 fine Tuning(파인튜닝)을 통해 결과의 정확도를 개선시켰다. 분류의 정확도를 높이기 위하여 librosa를 활용하여 매미소리의 17개 특성값을 추출하여 머신러닝으로 학습하였다. 12종의 매미 울음소리를 딥러닝 모델에 적용하였으며, 95%의 정확도를 확인하였다.

검색어: 소리분류, 딥러닝, 합성곱신경망, 인공지능, 기계학습, 매미, 분류

P304

Screening of Bacteria enzyme activity in *Tenebrionidae* Gut and research on Microbial-added Dog Snack Products

Sun Am Kim[1], Hui Yeon Koo, Yu Beom Lee, Sang A Oh, Ji Soo Kim, Hye Young Kwon, Do Ik Kim and Kyung Chun Joo
Extension Services Insect & Sericultural Research Institute, Jeollanamdo Agricultural Research

최근 산업곤충 활용방안에 대한 연구들이 활발히 진행되고 있다. 그중에서도 갈색거저리와 아메리카왕거저리에 대해서 장내 미생물 5종을 분리하여 장내미생물을 활용한 산업화 활용방안에 대한 연구를 수행하였다. 갈색거저리 장내미생물을 선발한 미생물 군집을 비교한 결과 *Lactobacillus rogosae, Bfidobacterium adolescentis, Bfidobacterium longum, weissella confusa* 순으로 0.77%, 0.46%, 0.19%, 0.03%로 나타났으며 아메리카왕거저리 장내미생물은 *weissella confusa, Lactobacillus graminis, Bfidobacterium adolescentis, Bfidobacterium longum* 순으로 4.58%, 0.75%, 0.13%, 0.01%로 나타났다. cellulase, amylase, protease, lipase 효소활성시험을 통해 활성이 우수한 거저리류의 장내미생물 *Weissella cibaria, Bacillus paralicheniformis, Pediococcus pentosaceus, Bacillus velezensis, Hafnia alvei 5*종을 선발하였다. 선발된 미생물 중 반려견 치석 제거용 덴탈스틱 개발을 위해 *Streptococcus mutans* 균을 대상으로 구강유해균 억제능을 확인하여 *Weissella cibaria* 균주를 선발하였다. 제품개발을 위해 미생물 첨가비율에 따른 배합비를 통해 *Weissella cibaria* 균주 1×10^6 처리구에서 선호도가 가장 좋았으며 일반성분의 경우 시판제품에 비해 1×10^6 처리구에서 단백질, 지방, 회분, 수분의 함량이 가장 높았으며 색도 또한 가장 높은 수치를 나타내었다.

검색어: 거저리류 장내 미생물, 미생물 분포상, 덴탈스틱,

P305

Investigating variety effects of major summer crops using indoor breeding methods of Lepidoptera pests in Gangwon provinces

Suhyoung Park, Sera Kang, Jang Gyu Choi and Jeongtae Lee
Highland Agricultural Research Institute, National Institute of Crop Science, Gyeonggang-Ro 5481, 25342, Korea

The fast adaptation of moths, especially the Lepidoptera pests are being used as indicators of climate change. We tried to investigate the effects of variety in major summer crops of Chinese cabbage, potato and corn. Using indoor breeding system of Lepidoptera pests, we selected larvae of Helicoverpa armigera hatched 6~7 days, Spodoptera exigua, hatched 3~5 days ago about 1 cm length. Among 4 commercial variety of Chinese cabbage, 'Odae'gathered many larvae of Helicoverpa armigera. Potato variety of 'Suji'and corn variety of 'Mi Baek' gathered many larvae, respectively. Using Spodoptera exigua, Chinese cabbage variety of 'Cheong Ok', potato variety of 'Sumi'gathered many larvae. We found that Lepidoptera larvae showed variety preference in Chinese cabbage, potato and corn. However the average number of Helicoverpa armigera larvae in each crop was 10, 2.2 and 6.6, respectively. Thus we selected Chinese cabbage for further study of testing pesticides resistance. This result will be used for eco-friendly production of major summer crops in Gangwon provinces.

Key words: Lepidoptera, larva, Chinese cabbage, potato, corn

P306

Rapid Development of Microsatellite markers for *Eumeta variegata* using NGS data

Shin Ae Lee, Hye Min Seo, Jin-Ho Kim, Hae Lim Kim, Jun Seong Jeong Kyung and Jun Lee
Division of Genetic Resources, Honam National Institute of Biological Resources

The bagworm (*Eumeta variegata*) is a well known pest on orchard and street trees. However, a lack of genetic information of this pest results in a series of genetic questions remain largely unknown, including population genetic structure, kinship and biotype abundance. Co-dominant microsatellite markers offer a great resolving power to determine these events. Here, we report rapid microsatellite (MS) isolation from *E. variegata* via high-throughput sequencing data on NCBI. Using genomic sequencing data (PRJDB7096), 850 MS loci were detected and a suit of 332 primer pair sequences were designed. Using *in silico* PCR analysis, 24 out of 205 candidate MS markers were selected and used to analyze the genetic diversity of 44 bagworms collected from two species of trees. The results showed the twenty four MS loci were polymorphic between populations. These novel markers are valuable for future genetic mapping, trait association, genetic structure and kinship among *E. variegata.*

Key words: *Eumeta variegata*, Genetic diversity, Microsatellite marker

P307

Study of the decomposition of agricultural by-product and frass using Black Soldier Fly (BSF)

Bonwoo Koo, Ji Yeong Park, Eunsun Kim, Youngsoon Kim and Kwanho Park
National Institute of Agricultural Sciences, RDA, Wanju 565-851, Korea

Agricultural by-products occur at all processes of agricultural production including production, processing, manufacturing, and distribution of agricultural products. There is a need for an eco-friendly way to treat and reduce agricultural by-products. Black Soldier Fly (BSF) could be one of the method which treat agricultural by-products. This study investigated the decomposition of apple pomace and frass using BSF larvae. The larvae fed with apple pomace took 26 days to become pupae compared to the larvae which fed with cattle feed (12 days) as a control, The weight of larvae fed with apple pomace was smaller than the weight of larvae fed with cattle feed. The frass of the larvae fed apple pomace met the fertilizer process standard. It will be possible to resource agricultural by-product at the same time as eco-friendly treatment by using larvae in BSF.

Key words: Black soldier fly, fruit by-products, frass

P308

Investigation on host plant preference of *Bemisia tabici* and its managemental application

In-hong Jeong, Meeja Seo,Dagyeong Jeong, Gwan-seok Lee, Ye-yeon Gwak and Hong-Hyun Park
Crop protection Division, National Institute of Agricultural Sciences, RDA

국내 시설재배에서 대표적인 문제해충인 담배가루이 성충에 대하여 4-choise test를 활용하여 기주선호성 조사를 실시하였다. 담배를 기주로 수년간 사육한 성충은 가지과 작물 8종(담배, 까마중, 구기자, 고추, 피망, 독말풀, 가지, 페튜니어) 가운데 담배(40%),가지(32%), 까마중(17%), 피망(11%) 순으로 선호성을 보였다. 이들 4종 가운데 가지를 기주로 1세대이상 사육한 성충은 가지(36%), 까마중(33%)의 선호성이 높았으며, 토마토를 기주로 사육 했을 때는 담배(43%)의 선호성이 월등히 높아 사육 기주에 따라 선호성이 달라짐을 알 수 있었다. 토마토 기주에서 사육한 담배가루이에 대하여 2-choice test에서도 담배(65%)에 대한 선호성이 토마토(35%)보다 높았다. 또한 디노테퓨란 입제(2%)를 주당 3g처리한 담배에서 침투이행에 의한 담배가루이 성충의 약효는 처리 후 4일차(97.4%)와 21일차(방사 2일후 100%)에도 높게 유지됨을 확인할 수 있었다. 따라서 선호성이 높은 기주식물을 활용한 침투이행성 약제처리가 포장내 담배가루이 밀도 감소에 영향을 줄 수 있음을 시사한다.

검색어: 담배가루이, 기주선호성, 침투성 약제, 방제효과

P309

Microinsect pests on imported cut flowers in Korea during 2011-2020

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

In this study, we focused on microinsects(Thysanoptera and Aleyrodidae) found in imported plant seedlings and cut flowers from 2011 to 2020 using pest information system. A total number of 36 detection records containing thrips in plant seedlings and 6,129 founds in imported cut flowers to Korea. Aleyrodidae was found in Plant seedling and Cut flower account for 57 and 1,015, respectively. *T.tabaci* is the most thrips found in seedlings. *Frankliniella occidentalis*, *T. tabaci* and *F. intonsa* accounted for more than 70% of the total number of thrips detected in cut flowers. They have been shown a lot in chrysanthemums and carnations. *Bemisia tabaci* and *Trialeurodes vaporariorum* of the aleyrodidae were mainly detected in rubber tress seedlings. *B. tabaci*, and *T. vaporariorum* accounted for more than 90% of the cut flowers, and 85% of them were found in chrysanthemums.

Key words: Plant quarantine, Thysanoptera, Aleyrodidae, Cut flower, Seedling

P310

Library of high-resolution images on plant quarantine pests in Korea

Ah-Ram Son and Sang-mok Kim
Plant Quarantine Technology Center, Animal and Plant Quarantine Agency, Gimcheon 39660, Korea

High-resolution images of the specimens are needed to identify for insect through the diagnostic characteristics as a taxonomic key. The images on pest specimens for quarantine purpose is not sufficient due to the low quality of resolution and characterisitics for identification on insects. Therefore, high quality images are strongly needed. Animal and Plant Quarantine Agency produced about 800 high-resolution images as photographs and plates from 2021 to August 2022. Coleopteran insects are most taken as 372 cases (46.5%), followed by Lepidopteran as 176 cases (22%), Hemipteran insect as 147 cases (8.4%), and Dipteran insects as 87 cases (10.9%). Library of high-resolution images on pests will be used for classification and identification to alien insect speices for plant quarantine inspection.

Key words: High-resolution image, plant quarantine, insect, characteristics, classification

P311

Trend of plant quarantine pests on imported seedlings (41 items) in Korea

Yu-Ri Kim and Sang Mok Kim
Plant Quarantine Technology Center, Animal and Plant Quarantine Agency, Gimcheon 39660, Korea

Using the Pest Information System (PIS), we analyzed on 41 items of imported seedlings over the past 20 years. One hundred eighty five genus (250 species) were detected among 41 items of seedlings including *Vitis* spp., *Arecaceae* spp., and *Cattleya* spp. Tylenchida was the most common pest as 35.9%, followed by Hemiptera as 15.4%, Hymenoptera as 14.3%, and Coleoptera as 10.4% in detection rate. Among regulated pests from 41 items, *Radopholus similis* in Tylenchida was only detected species as prohibited pest, meanwhile 72 insects species are detected as managed pests including *Pseudococcus longispinus*, *Dysmicoccus neobrevipes*, and *Dysmicoccus brevipes* in Hemiptera and *Tapinoma melanocephalum*, *Tetramorium simillimum*, and *Paratrechina longicornis* in Hymenoptera.

Key words: plant quarantine, seedlings, quarantine pests, identification manual, PIS

P312

Safety assessment of frame used for honeybee (*Apis mellifera* L.) breeding and production of bee products

Hyo Young Kim, Se Gun Kim, Hong Min Choi, Seon Mi Kim and Sang Mi Han
Department of Agricultural Biology, National Institute of Agricultural Science, RDA

꿀벌은 축산법에서 소·말·돼지 등과 같이 가축으로 정의하고 있으며, 꿀벌로부터 얻어지는 양봉산물은 축산물로 정의하고 있다. 현재 국내의 축산농장 (한우·젖소·돼지 등) 생산단계 HACCP 관련 내용은 축산물 위생관리법에서 규정하고 있는데 꿀벌은 제외된 상황이다. 축산농장 생산단계 HACCP은 가축의 사육단계에서 발생할 수 있는 위해요소 (동물용의약품, 살모넬라균 등)를 분석하여 중점관리 할 수 있는 기준을 정하고 인체에 위해한 물질이 축산물에 오염되거나 혼입되는 것을 방지하는 제도이다. 한편, 전 세계 급변하는 기후변화는 전국적으로 양봉농가에 월동봉군 피해를 안겼고, 근본적인 해결책을 위해서는 다양한 연구가 필요하다. 따라서 본 연구는 양봉농가 생산단계 HACCP 도입에 앞서 꿀벌 육종과 양봉산물 생산에 필수적인 소광대의 식품용 기구로서 안전성을 알아보고자 하였다. 시험에 사용된 소광대는 시중에 판매하는 소광대를 구입하여 재료로 사용하였다. 식품용 기구 및 용기·포장 공전의 목재류 항목 분석 (mg/L) 결과 비소는 기준치 이하 및 불검출, 납은 기준치 이하 그리고 이산화황, 오쏘페닐페놀, 티아벤다졸, 비페닐, 이마잘릴은 모두 불검출로 나타났다. 따라서 이러한 결과는 양봉산물 생산에 직·간접적 재료로 사용되는 소광대의 품질 데이터베이스 구축 및 양봉농가 생산단계 HACCP 연구에 기초자료로 활용될 수 있음을 시사한다.

검색어: 서양종꿀벌, 육종, 양봉산물, 소광대, 안전성

P313

Biological characteristics and mass rearing of Korean *Luciola lateralis* Motschulsky (Coleoptera: Lampyridae)

Do-Hwan Jang[1] and Bong-Kyu Byun[2]
[1]Dept. of Zoological Management, National Institute of Ecology, Seocheon, Korea
[2]Department of Biological Science and Biotechnology, Hannam University, Daejeon, Korea

본 연구를 통해 애반딧불이의 생태와 대량사육법을 조사하였다. 또한 이들의 실내 대량사육시 효율적인 실내 대량사육을 위한 인공 산란장소의 이용과 자동 물 교환 시스템을 적용하여 유충의 유실을 최소화하고 사육에 소요되는 시간을 크게 단축하는 성과를 도출하였다. 이외에도 유충의 저온 저장 가능성 조사를 통해 애반딧불이의 개체를 연구 상시 확보 할 수 있는 기초자료를 수립하여 제시하였다.

검색어: 애반딧불이, 생태, 대량사육, 유충관리

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KSAE

60th Anniversary

S1

Introduction of the education program for farmers adopting biological control practice

Duck-Oung Jung[1,2], Hwal-Su Hwang[1] and Kyeong-Yeoll Lee[1,2]
[1]Department of Applied Biosciences, Kyungpook National University
[2]Sustainable Agriculture Research Center, Kyungpook National University

경북대학교 친환경농업연구센터에서는 토양 포식성 천적인 총채가시응애(*Gaeolaelaps aculeifer*)와 뿌리이리응애(*Stratiolaelaps scimitus*)의 효율적인 국내 보급 및 실용화를 위하여 간편한 저비용 대량생산기술을 개발하고 농업인을 대상으로 실습교육을 통한 농가 보급을 추진하였다. 2016년부터 경북농민사관학교의 지원하에 약 150여명을 농업인을 교육하였고 농업인들이 스스로 천적을 자가생산하여 시설재배지에 적용함으로서 비용절감 및 청정 농산물 생산 효과를 높히는데 기여했다. 또한, 지자체 농업기술원, 농업기술센터, 그리고 친환경농업인단체 등 20개 기관에 저비용 천적생산기술을 전수하였다. 최근, 시설재배작물의 주요 해충인 점박이응애(*Tetranychus urticae*) 방제에 효과적인 포식성 천적인 칠레이리응애(*Phytoseiulus persimilis*)와 사막이리응애(*Neoseiulus californicus*)를 간편하게 저비용으로 생산할 수 있는 기술을 개발하고 다양한 방법으로 전수하였다. 본 연구는 천적 사육 및 보급 시스템을 다양화함으로서 국내 천적농업의 활성화에 기여했다고 판단한다.

검색어: 포식성천적, 총채가시응애, 뿌리이리응애, 칠레이리응애, 사막이리응애

S2

A case study on the management of “Jeollabuk-Do Natural Enemy Farming Society (JBNEFS)”

Seon-U Choi[1], Sang-Young Seo[1], Hyo-Jung Choi[1], Young-Sook Oh[2] and Min-Sil Ahn[1]
[1]Jeollabuk-do Agricultural Research and Extension Services
[2]Gunsan Agricultural Technology Center

‘전라북도천적농업연구회’는 전라북도내 익산과 군산지역 농업인이 주축으로 구성되었다. 전라북도농업기술원 연구개발국에서 기술, 행정, 예산 등을 지원하고 있다. 2016년부터 천적활용에 대한 관심을 가지던 친환경 농업인을 중심으로 2020년 1월에 창립되었다. 현재 82명의 회원이 활동하고 있다. 농업인은 실패를 하면서도 천적활용기술을 하나씩 습득하고 서로 정보를 공유하여 왔다. 전라북도농업기술원은 농업인이 천적을 안정적으로 활용할 수 있도록 ‘천적 품질관리 매뉴얼’ 번역서를 발간하여 교육을 실시하였다. 또한 농업인 실습형 천적 자가증식실을 운영하여 174회 7백3십만마리를 분양하였다. 군산시농업기술센터는 군산시, 전라북도, 농촌진흥청의 시범사업을 적극적으로 활용하였다. 2021년 7월에는 ‘천적활용 생산 농산물 홍보 및 판매행사’를 추진하여 연구회원의 기술력을 홍보하는 결집력도 보여줬다. 공공기관과 농업인이 협력한 연구회 운영은 천적활용기술이 현장에 정착되기 위해서는 일회성보다는 지속적인 지원이 필요함을 보여주는 우수사례이다.

검색어: 전라북도천적농업연구회, 농업인, 천적활용, 친환경

S3

Biological control strategy of thrips using *Ocimum basilicum* with *Orius laevigatus* (Fiber)(Hemiptera: Anthocoridae) in cucumber greenhouse

Yong-Seok Choi, Yoon-Sung Won, Gun-Woo Lee, In-Soo Hwang, In-Soo Hwang and GyeongJu Lee
Chungnam Agricultural Research & Extension Services, Yesan 32418, Korea

The cucumber flower does't seem to be supplying enough nectar and pollen to the natural enemies. Among the natural enemies that can be used in the cucumber greenhouse, especially *Orius laevigatus* may require flower nectar and pollen for settlement and reproduction. Actually we have experienced that *O. laevigatus* good at settling in cucumber greenhouse and sometimes not. Therefore we tried to evaluate the potential as banker plants of *O. laevigatus* with 4 plants. The emergence rate was the highest in *Ocimum basilicum*. The hatching rate, the survival rate in *O. basilicum* was not statistically different from *Portulaca grandiflora.* The fecundity and the oviposition period in *P. grandiflora* was little higher and longer than *O. basilicum*. The flowering period of *O. basilicum* was from April to October and the flowering period of *P. grandiflora* was July to August. Finally, we selected *O. basilicum* with long flowering period as banker plant in consideration of *O. laevigatus* that prefer the flowers.

Key words: Cucumber, *Orius laevigatus*, *Ocimum basilicum*, Banker plant, Biological control

S4

The present and future of natural enemy research in Gyeonggi province

Seung-Hwan Yun, Sang-Youn Sim, Jong-In Choi, Jeong A Han, Dong-Hyeon Jo and Jung-Soo Park
Gyeonggi-do Agricultural Research and Extension Services, Hwaseong 18388, Korea

최근 유기농업 면적의 증가, 난방제 해충에 대한 화학적 방제법의 한계, PLS제도 도입 등으로 기존 화학농약을 보완할 수 있는 천적의 필요성이 향후 증대될 것으로 예상된다. 이에 경기도는 신규 천적의 도입을 위해 국내 자생하는 토착천적을 발굴하여 생태특성을 구명하고 활용법에 대한 연구를 추진 하였다. 현재 경기도에서 개발한 천적인 네점가슴무당벌레와, 벗초파리기생벌의 현장 이용법에 대한 연구 및 토마토에서 생태공학적 기법을 활용한 천적이용 기술에 대한 연구를 수행중이다. 향후 경기도의 천적연구 방향은 우선 경기도의 주요 작목별 기 개발된 천적의 효율적인 사용방법을 단계적으로 마련해 나갈예정이다. 또한 여기에 천적 만이 아닌 농약 및 기타자재 등을 종합적으로 활용한 관리기술을 수립하고 곤충생리적 접근을 통한 천적의 유인/기피 반응을 유도하는 물질의 탐색과 적용을 통해 현장에서 천적의 활용도를 높일 수 있는 기술을 개발하고자 한다.

검색어: 경기도농업기술원, 천적, 연구현황, 향후 계획

S5

Aspects on Biological Control of Tree Pest

Gun Hyung Kwon
Gyeonggi-do Forestry Environment Research Center

나무는 산림에서 뿐만 아니라 도시지역에서도 경관 형성을 위하여 수 많은 나무들이 우리주변에서 공존하고 있다. 이들 수목은 농작물과 비교하여 열매를 수확하는 등 직접적인 경제적 효과를 주지는 않지만, 경관을 형성하거나 간접적인 무수한 이익을 인간들에게 주고 있다. 이러한 수목을 보호하기 위하여 다양한 방법들이 개발되어 이용되어 왔지만, 현재까지 가장 효과적인 방제방법은 화학적 방제가 주를 이루고 있다. 그러나 이러한 화학적 방제방법은 최근 지속적으로 여러 가지 환경문제가 대두되고 있어 친환경 방제에 대한 요구가 점차 커지고 있다. 산림내 수목의 경우 주요 해충을 비롯하여 다양한 해충 방제를 위하여 생물학적 방제방법에 대한 연구가 지속적으로 수행되어 왔으나, 산림과 같은 복잡한 생태계에서 효과적인 방법의 개발은 매우 어려운 실정이다. 사람들이 일상생활을 영위하는 장소에 심어져 있는 생활권 수목에서도 병해충 방제를 위해 다양한 농약이 살포되고 있으나, 농약의 오남용 등의 문제가 발생하고 있다. 그러나 현재까지 생활권 수목에 대한 해충 방제방법의 연구는 경제성을 가진 농작물에 비해 관심과 투자가 떨어져 매우 기초적인 단계이지만, 국민들의 인식의 변화가 이루어진다면 향후 많은 가능성을 가질 수 있는 분야로 판단된다.

검색어: 생활권 수목, 화학적 방제, 생물적 방제, 수목 해충