About This Issue

Welcome to another IRAC eConnection Newsletter. As always we try to bring you interesting and informative articles about the work of IRAC and insecticide resistance news from around the world.

In this issue we have details on some changes in the management of the Arthropod Pesticide Resistance Database, an update on the status of insecticide resistance in the mosquito vectors of malaria with information on some new initiatives. IRAC continues to develop new educational resources and IRM guidelines and we outline some of the most recent examples along with other IRAC news. As we move towards the end of March, IRAC will be holding their 51st International Meeting in Philadelphia with around 45 participants expected. We will provide more details on this in the next issue.

Remember, if you have any news or resistance topics of interest, please let us know so that we can inform others in the IRAC Network. We hope you enjoy the issue.

Changes for the Arthropod Pesticide Resistance Database

The Michigan State Arthropod Pesticide Resistance Database (APRD) is a web-based resistance case entry system that serves as a centralized tool to access arthropod resistance information and determine the current status of arthropod resistance across the globe, with cases dating back to 1914 (www.pesticideresistance.org). The web database program has been directed by Dr. Mark Whalon and Michigan State University since the early 1990s, and co-directed by Dr. David Mota-Sanchez and Dr. Robert Hollingworth. IRAC International and IRAC US have provided advice and expertise on the database inputs and outputs, as well as financially supported the database since the early 1990s. Dr. Whalon has also received additional funding from other entities such as the USDA, CSREES Pest Management Alternatives Program, Generating Research and Extension to meet Economic and Environmental Needs (GREEN) Project #GR02-69, Michigan Agricultural Experiment Station, Michigan State University Extension and the Michigan Department of Agriculture.
At the end of 2017, Dr. Whalon will be retiring from Michigan State. IRAC would like to take this opportunity to thank Mark for all of his dedication and many years of service. Without his continued drive and commitment to operating the database, we would not have such an important resource available to us today!

During this transition, we are excited to announce that Dr. Mota-Sanchez and Dr. John Wise, will be taking on the responsibility of co-directing the resistance database for the future, with support of Entomology Department Chair Dr. Bill Ravlin. Dr. Mota-Sanchez is an Assistant Professor in the Department of Entomology and has been involved with the resistance database since the early days of its inception, has an excellent history and in-depth knowledge of its inner workings and has been the principle student data-entry trainer for the database programmers. Dr. Wise is a Professor in the Department of Entomology. He is the Director of the IR-4 Central North Region Unit and Research and Extension Coordinator of the Trevor Nichols Research Center, the largest field pesticide testing facility in the Upper Midwest, runs the Applied Insect Toxicology lab on the Michigan State campus, and has a long history of working with insect toxicology and insecticide resistance.

The resistance database went through a major transition in 2015 to 2016 and has had many improvements in functionality. The coding system for the database was antiquated and in serious need of updating to a new platform in order to make desired improvements. IRAC International supported this upgrade, which allowed the resistance database team to improve search functionality so users can search for resistance cases based on new criteria such as country of origin, insecticide mode of action or by an arthropod’s family or order. In addition, multiple search criteria can now be used simultaneously, providing the ability to much more precisely query the database for resistance cases. Other improvements that are planned for the database include the addition of another category – field-evolved resistance or laboratory selected resistance – which will greatly improve our ability to segment cases that are pertinent to practical resistance and improve use for regulatory risk assessment. Drs. Whalon, Mota-Sanchez and Wise are always striving to make the resistance database as user-friendly as possible, all while constantly continuing to update new resistance cases as they are reported. In addition, the new platform enhances the ability to generate reports on resistance (see Table 1 and 2) to better understand annual changes and trends by pest, geography, chemistry, etc.

If you have any corrections or suggestions on how the database can be improved, please contact Dr. Mota-Sanchez at motasanc@msu.edu, Dr. Wise at wisejohn@msu.edu or Brad Hopkins, liaison from IRAC to the resistance database, at bwhopkins@dow.com.
Insecticides and insecticide resistance in the mosquito vectors of malaria

Insecticides play a key role in the prevention of insect vectored pathogens such as the plasmodium parasites that cause malaria, or Zika and Dengue virus. Since 2000 there has been a 40% reduction in the incidence of clinical malaria, with an estimated 663 million clinical cases averted. 87% of this gain has been attributed to the large scale use of insecticide treated long lasting bed nets (LLIN) and indoor residual wall spraying (IRS) (Bhatt et al, 2015). However, many now consider this success to be under threat by ever increasing levels of insecticide resistance in the anopheline vectors of malaria (Hemingway et al, 2016).

All currently recommended LLINs are impregnated with one class of insecticide, the pyrethroids. With the commendable World Health Organisation (WHO) recommendation for universal access to LLINs, for those at risk of malaria, mosquito populations in malaria endemic regions face almost constant selection pressure with pyrethroids. We shouldn’t therefore be surprised that susceptibility to pyrethroids in the mosquito vectors of malaria is falling. There have even been reports of pyrethroid resistant mosquitoes entering damaged LLINs and taking blood meals (Ochomo et al, 2013). However, it has also been noted that when a malaria control programme in Ghana switched from pyrethroid to organophosphate based IRS, the incidence of parasitemia (the presence of the malaria parasites in blood) significantly fell (Ricks, 2015). Whilst not proving an underlying link between pyrethroid resistance and a reduction in malaria control, it suggests that it could be a problem.

Currently only insecticides from four IRAC mode of action sub-classes are recommended for the control of adult mosquitoes; pyrethroids (3a), DDT (3b), carbamates (1a) and organophosphates (1b). The dearth of insecticidal modes of action available for adult mosquito control has a number of reasons, including the development of public health insecticides potentially having a poor return on investment. Historically, insecticides have been developed that could be used in both agricultural and public health, e.g. pyrethroids or organophosphates. However, over the last 30 years regulatory pressure and environmental concerns have focused insecticide development on those with a limited spectrum and physical characteristics that are less suitable for use as classical mosquito adulticides. As a result, no insecticides from mode of action groups outside of 1 and 3 have been recommended by the WHO since in the 1980s.

The good news is that this is being addressed, and a number of initiatives are underway with the aim of developing novel solutions for the control of malaria vectors. These including public private partnerships, such as the Innovative Vector Control Consortium (IVCC), aimed at facilitating the research and development required to deliver novel vector control insecticides. Other initiatives are expediting the transition of novel vector control concepts to effective interventions, e.g. Innovation to Impact (I2I). The next few years will hopefully see a number of novel and effective mosquito adulticides being brought to market.

In any effective IRM programme an understanding of the susceptibility status of the target pest population to the available insecticidal modes of action is required. The most appropriate insecticide to use can then be identified. Currently, in vector control, where there are limited insecticides available, and significant insecticide resistance, it is appropriate to identify which insecticides will provide the best level of control of the mosquito population, i.e. which still provide the desired duration of protection. However, when novel insecticidal modes of action become available, measuring smaller changes in the susceptibility of the population will become an important part of the “susceptibility maintenance” programmes that should be implemented to gain the greatest utility from these new insecticides. In the context of malaria vector control, this shift from resistance to susceptibility monitoring is analogous to the use of a smoke detector, to warn of fire, rather than looking to see which buildings haven’t yet been burnt to the ground.
In agriculture IRM is always more effective when implemented as part of an Integrated Pest Management (IPM) programme. Likewise in vector control, IRM or perhaps “insecticide susceptibility maintenance”, should be implemented in the context of an Integrated Vector Management (IVM) programme. IVM has been defined as “a rational decision-making process for the optimal use of resources for vector control. The approach seeks to improve the efficacy, cost-effectiveness, ecological soundness and sustainability of disease-vector control” (WHO, 2014). To remain sustainable, the utility of the novel insecticides currently being developed and brought to the market need to be maintained. This can only be achieved by making the vector control programmes more resilient to resistance development, through the use of effective IRM in the context of IVM.

The ongoing activities facilitating and expediting the development of novel vector control interventions may be a once in a generation opportunity. It is therefore vital that the effectiveness of new public health tools is maintained for as long as possible through their use in “resistance resilient” vector control programmes.

The IRAC Public Health team has produced a manual outlining best practice IRM in vector control. A summarised version is also available in English and French.

Useful links:


I2I: [http://innovationtoimpact.org/](http://innovationtoimpact.org/)


References:


New Insecticide Resistance Management Posters from IRAC

The European Grapevine Moth, Lobesia botrana
Recommendations for Sustainable and Effective Resistance Management

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Lobesia botrana - Background
Lobesia botrana (Polyphagous) is also known as the European grapevine moth (ECDM) or a major pest of deciduous fruit trees in the Northern Hemisphere. It is a moth that can spread throughout Europe, North America, and Asia. This pest is found in the United States, Mexico, and Argentina. Insecticides are critical to the control of this pest. The insecticides used to control this pest are highly toxic and have been widely used for many years. The resistance management strategy of Lobesia botrana is outlined in the following sections.

Life Cycle
Lobesia botrana has a complex life cycle, with several generations per year. The egg stage lasts about 10 days, and the larval stage lasts about 25 days. The adult stage lasts about 10 days. The adult moths are active during the day and are attracted to lights. The occurrence of multiple generations, the ability to migrate, and the ability of the adult to develop a range of host plants makes early detection one of the most important aspects of managing this pest.

Insecticide Resistance Management
Control of Lobesia botrana is essential to prevent further spread of the moth and to prevent the development of resistance. The following recommendations are designed to prevent further spread of the moth and to prevent the development of resistance.

Key Management Strategy: Integration of Control Measures
The basis for effective and sustainable management of Lobesia botrana is the integration of cultural, biological, chemical and insect management tactics.

Cultural
- Timing decisions
- Crop rotation
- Host plant resistance
- Cultural practices

Biological and chemical management
- Pesticides
- Insecticides
- Biopesticides

Chemical
- Insecticides
- Mitigation strategies

Depending on availability of effective MOA

www.irac-online.org/documents/lobesia-botrana-poster/?ext=pdf
www.irac-online.org/documents/spodoptera-frugiperda-poster/?ext=pdf

Strategies for Sustainable Control of Fall Armyworm, Spodoptera frugiperda

FAW - Background
Fall armyworm (FAW), Spodoptera frugiperda (Lepidoptera) is an economically important insect pest that occurs in large numbers in the Americas, Australia, and Africa. FAW is a very versatile pest, with a preference for grasses. It is a major pest of both cereal and non-cereal crops, and it is a serious threat to the global food supply. FAW has a complex life cycle, with several generations per year. The egg stage lasts about 10 days, and the larval stage lasts about 25 days. The adult stage lasts about 10 days. The adult moths are active during the day and are attracted to lights. The occurrence of multiple generations, the ability to migrate, and the ability of the adult to develop a range of host plants makes early detection one of the most important aspects of managing this pest.

FAW IRM example - Spraying windows for conventional maize, Brazil

Known insecticide resistance in FAW
Resistance results from the repeated exposure of multiple pest generations to the same insecticide or to different insecticides from the same class. Resistance mechanisms in FAW include metabolic resistance, target site resistance, and target site modification. Metabolic resistance is the most common resistance mechanism in FAW. This mechanism involves the detoxification of insecticides by the pest. The resistance management strategy of FAW is outlined in the following sections.

FAW Resistance Management
To prevent the development of insecticide resistance, a combination of available pest management and resistance management tools must be implemented. The following recommendations are designed to prevent further spread of FAW and to prevent the development of resistance.

www.irac-online.org/documents/fall-armyworm-poster/?ext=pdf
www.irac-online.org/documents/lobesia-botrana-poster/?ext=pdf
www.irac-online.org/documents/spodoptera-frugiperda-poster/?ext=pdf
IRAC News Items

*Tuta absoluta* Best Management Practices

The *Tuta absoluta* Task Team operating within the IRAC Lepidoptera WG have now published Best Management Practices (BMP’s) to control *Tuta absoluta* and manage resistance. Shown below is the front page and table of contents of the document.


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**AgBiTech joins IRAC International**

AgBiTech is the latest company to join the long list of IRAC members. They are a company with a dedicated focus to expand the availability and use of Baculovirus-based bio-insecticides. AgBiTech are heavily investing in the global development, manufacturing and commercialization of high quality nucleopolyhedrovirus (NPV) products as effective tools for lepidopteran pest management to support conventional programs, and as “foundation” products in Integrated Pest Management systems. Their mission is to make NPV technology a global mainstream tool for pest management, and to help extend the effective life of vital pest control technologies, in particular genetically modified crops and new chemistries that are beginning to develop resistance.

**Insecticide Resistant Strain Collection (IRSC) for Resistance Management.**

A concern in the development of new insecticides is the issue of whether or not there will be cross-resistance in pest populations due to prior insecticide use. IRAC and its member companies are pleased to announce a new resource for members: The Insecticide Resistant Strain Collection (IRSC) for Resistance Management. This collection of insecticide resistant strains will provide an invaluable tool for being able to assess the potential for cross-resistance. Strains of the resistant insects will be sent to participating IRAC companies free of charge (companies must pay the costs for shipping and have appropriate permits if they are outside of the USA). Companies can also make arrangements to have strains confidentially tested by the IRSC staff for a modest fee. Visit the web site below for a listing of the strains that are currently available.


**Mode of Action Classification of Afidopyropen as Group 9D - Pyropenes**

A MoA classification for afidopyropen as Group 9D was approved by the IRAC MoA WG and the IRAC Executive based on its unique structure (relative to pymetrozine and pyrifluquinazon) and lack of cross-resistance to pymetrozine. Afidopyropen will be added to the MoA Classification Scheme once a registration is achieved. At the moment it is listed in Appendix 6 of the Scheme (pending registration).
IRAC IRM Video now available in 6 languages plus English

The English version of the IRAC Insecticide Resistance Management Video has proved so popular that we have now translated the video into 6 other languages. These are Latin American Spanish and Portuguese, Mandarin, Japanese, French and Hindi and can be viewed on the IRAC website (http://www.irac-online.org/teams/outreach/). A second video focusing on mode of action is currently in production.

Disclaimer: The Insecticide Resistance Action Committee (IRAC) is a specialist technical group of CropLife. Information presented in this newsletter is accurate to the best of our knowledge but IRAC and its member companies cannot accept responsibility for how this information is used or interpreted. Advice should always be sought from local experts or advisors and health and safety recommendations followed.