

Fruit Flyer



FFIPM Bulletin • ISSUE 10 • February 2024





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This is the t Newsletter Publication of the EU-funded research project FF-IPM, with the aim to protect fruit production and trade from threats posed by fruit flies.

The newsletter is published quarterly, highlighting the actions, news, progress related to the issue at hand.

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The editorial for the 10th FF-IPM newsletter

Nikos Papadopoulos, Marc De Meyer, H el ene Delatte, Filippos Karamanlis, Darren Kriticos, Slawomir Lux, and Josep Vacas and the FF-IPM partners

A quite interesting journey in fruit fly research in Europe has just ended. The FF-IPM project, working intensively to address fruit fly invasion in Europe for almost five years, has just concluded. The FF-IPM project kicked off in September 2019, at a time that only few tropical fruit flies had been detected in Europe (e.g. *Bactrocera zonata* and *Bactrocera dorsalis* in Austria, *B. dorsalis* in Italy) and only few sporadic occurrences of the Mediterranean fruit fly (medfly), *Ceratitis capitata* were known from central European countries. During the course of the FF-IPM project detections of *Bactrocera dorsalis* became more frequent and dispersed involving additional countries (e.g. France, Belgium) and a major outbreak has been reported in Italy. Surveillance activities revealed interesting detection patterns for medfly in several countries in central Europe as well as occasional fruit infestation in late ripening hosts. Hence, our project was timely accepted and executed and its outcomes are of high relevance for addressing the invasion and range expansion of the three target species in Europe. In addition, the coordinated and focused research performed resulted in a list of tools that can be considered in the preparedness of EU against invasive fruit flies and may also assist management operations for established species.

The FF-IPM project kicked off in September 2019, at a time that only few tropical fruit flies had been detected in Europe.

The main goal of our project was to “develop holistic knowledge-based approaches, innovative tools and services, to empower stakeholders across all sectors along the fruit production and processing chain to (a) dynamically address the impending risks of FF invasion, and (b) efficiently apply FF management throughout a spatial and seasonal continuum in a comprehensive, multi-actor and locally adapted manner”. Thanks to work of the 21 partners the objectives of the FF-IPM project of the project have been fully achieved.

The FF-IPM project received great support from a group of experts who served in the advisory board. Hence, special thanks are extended to Rui Pereira, Yoav Gazit, Tony Clarke, and Fran oise Petter for supporting the FF-IPM activities over all the years. The project intensively interacted with a big group of stakeholders and several of the outputs were developed in close collaboration with them. The list of stakeholders is large and unfortunately, we cannot refer to each one. However, we would like to express our appreciation and thanks to them for all the support to the FF-IPM project.

The 10th newsletter is the last of the series produced during the course of the project thanks to the effort of a group of people that we would like to thank and acknowledge. Thanks are extended to Ana Larcher and Ulli Schiefer (ISCTE), to Georgia Pahlitzanakis, Elma Bali and Vassilis Rodovitis (UTH), and to Georgia Micheli and Marina Papadima (RNDO). Also, to many other FF-IPM partners who have contributed materials.

The current editorial note serves as a summary of the main achievements of the project and gives some future steps for adoption of the developed tools and approaches. Overall, the project (a) submitted 52 deliverables containing an extensive amount of information regarding the tools, strategies, methodologies and

approaches developed, (b) published more than 30 scientific papers in peer reviewed, high impact journals, (c) communicated findings to a large list of scientific events and disseminated its findings to a broad range of target stakeholders through meetings.

The cornerstone of the FF-IPM project was the generation of new knowledge on stress physiology, establishment and dispersion of the three target species. In addition, we worked on the overwintering capacity, the off-season breeding resources of medfly and the spatial and temporal genetic relatedness of its populations. The plastic and adaptive responses to thermal and hydric stress have been studied for the three species in laboratory trials focusing on wild fruit fly populations. The nutritional correlation of stress resistance has been explored in medfly and *B. zonata*. For *C. capitata*, plastic and adaptive responses to various environmental stresses have been determined and several populations obtained from a wide range throughout the northern hemisphere (from Israel to Austria) have been considered. The generated data form a comprehensive database that can be used for further analysis and refining modeling. The overwintering potential of different *C. capitata* populations in two hosts have been studied, revealing substantial and unexpected variation in overwintering dynamics among populations and hosts. Following two years of trials in three different habitats and considering different life stages of the fly, we found that *C. capitata* can overwinter in both open field and protected areas in the area of Split, Croatia, whereas only in protected urban areas in Vienna, Austria. The effect of propagule pressure on establishment success has been determined for *C. capitata* and *B. zonata*, following meticulously designed laborious lab experiments. Multiple introduction events are directly related to establishment success,

while temperature and the size of the founding population have more stochastic effects. The correlation between ambient temperatures, thermal acclimation, host trees and dispersal dynamics, studied in *B. dorsalis* and *C. capitata*, generated novel data of relevance for the detection capacity. The effect of thermal acclimation and ambient temperature on flight capacity has been studied for all three target species following the same protocol in three different laboratories. Establishment and detection of low-density populations was also addressed through a novel set of release-recapture studies with marked feral flies, in four different field sites over a period of two years. Overall, the recapture and hence detection rate of current trapping networks is limited (<1% of the released flies). Detection of adult females is much more challenging than that of males. Exploring the host status of fruitlets of various fruits as an early breeding resource of *C. capitata* revealed limited capacity of females to oviposit and complete development. Working on the seasonal and spatial genetic variation among *C. capitata* populations, in neither natural core nor marginal populations we found evidence for variation in genetic composition between flies trapped in the early season versus the late season. In the Vienna (Austria) population we have seen that isolated, small allotments with mixed fruits and vegetables can harbor a surprisingly diverse population with significant and independent year-to-year variation.

Development and enhancement of tools and methods that can be used in the prevention of introduction or spread of the target fruit flies has been achieved. The e-Nose (that could reliably identify fruit fly-infested from non-infested fruits by the recognition of infestation-specific volatiles organic compounds) was tested for all three target species on a variety of selected fruits (peaches, pears, apples, sweet oranges). For all fruits and target species, the specific volatiles were identified for different

combinations of different levels of infestation time and at different temperatures. These were then compared with the volatiles emitted by non-infested fruits under the same conditions. Unfortunately, during the validation procedure (when testing the developed model with a new dataset) the models did not perform satisfactorily. Although some of the models developed could predict infestation with an accuracy as high as over 90%, even these models didn't perform satisfactorily in the validation stage providing inconsistent results. Nevertheless, the wealth of generated data provides a foundation for further work in this direction. Two e-Traps: McPhail and Delta e-Trap, including image-analysis and software for automated "Early-Warning" have been successfully developed and tested, and can be used for routine surveillance and detection programs. Images of the trapped insects could be sent using the standard mobile network, which distinctly shortens the reporting time. Field testing in Europe and Africa revealed that the e-Traps turned out to be comparable to conventional traps. However, due to the high accuracy of identification through machine learning, and the remote inspection through images the e-Traps have several advantages over the conventional traps with regard to cost and reaction time. Development of a suite of identification tools, both morphology- and DNA-based, allow a rapid identification of any life stage of the target fruit fly species. The key for adults identification comprises 23 species of dacine fruit flies considered of importance to the EU and includes the three target species and closely related taxa. The third instar larval key comprises a more reduced set of 13 species. The finalized products are freely available for mobile phones both for the android and iphone systems. Two sets of LAMP (Loop Mediated Isothermal Amplification) were developed for *Ceratitis* and *Bactrocera* species. LAMP diagnostics allow a DNA-based identification of any life stage, without the need of a sophisticated molecular laboratory,

making them suitable for deployment at points of entry and without the need of specialized personnel. Large amount of DNA barcodes to enhance the existing reference databases have been developed by the FF-IPM project. In total, 1,854 specimens were DNA barcoded and made available through the main online library and BOLD (Barcoding of Life Data Systems) repository, as well as GENBANK. In addition, upon request of the European and Mediterranean Plant Protection Organization (EPPO), newly generated DNA barcodes as well as existing libraries generated by the partners involved, were made available to the EPPO-Q-Bank the reference database for DNA barcodes specifically geared towards pest species of relevance to the European Union. In total, DNA barcodes for 173 species were made available through the different open-access libraries. Alternative molecular identification tools, such as ITS 2 sequencing, have been explored and allowed differentiation of e.g. *B. carambolae* and *B. kandiensis*. Development of diagnostic genetic markers linked to particular geographical areas in order to enable tracing the origin of intercepted or detected specimens of the target species was also conducted. Samples from throughout the whole distributional range of each fruit fly were obtained from existing collections and external sources. Whole DNA extraction and whole-genome sequencing was applied and diagnostic SNPs identified. For *Bactrocera dorsalis* the adequacy could already be tested by reconstructing the invasion history of the islands in the Western Indian Ocean, as well as investigating the possible origin of recent detections of the species in Belgium.

Testing of Several IPM tools for OFF-Season and On-Season management of *C. capitata* has been concluded. Besides testing each of the tools (i.e. entomopathogenic nematodes, entomopathogenic fungi and exploitation of ground predators) separately, we also tested their compatibility. Our studies confirmed that nematodes applied OFF-season or at early

Development and enhancement of tools and methods that can be used in the prevention of introduction or spread of the target fruit flies has been achieved.

season before population build-up, reduce adult emergence and could provide a useful tool for a sustainable environmental-friendly way to control the medfly. Both the seeded cover of *Festuca arundinacea* and the mulch of straw proved equally effective at decreasing *C. capitata* adult emergence (77 % suppression compared to bare soil). However, the economic analysis of the different options showed that *F. arundinacea* was the cheapest one. The soil treatment with Botanigard® WP22 has the potential to reduce emergence of *C. capitata* OFF-season. Moreover, the soil temperatures of the apple and peach orchards in Italy, where field tests were carried out, are within the range of those allowing growth and survival of the EPF. From a practical/operational point of view, the use of a massive number of traps with a liquid retention system (for example Tephri traps or IPMT) in the field would involve a considerable management effort. In addition, wet traps may suffer high escape rates of the attracted individuals. Use of Tephri and/or IPMT dry traps with a registered insecticide, which is currently unavailable in both Greece and Italy should be considered. Considering all pros and cons of the used devices and the fact that the Decis® trap is registered or use in organic farming, its adoption in activities (female monitoring and mass trapping) of the WP6 can be justified. Tested tools are already adopted and are used for the execution of the FF-IPM generated management approaches.

To provide tools to help FF managers across the biosecurity continuum (pre- border, border and post-border) to be more efficient and effective we developed a real-time informatics platform to assist them. The platform delivers eight tools to help 1) preventing incursions through targeted inspection and better-informed phytosanitary policies, 2) detecting incursions quickly and better manage containment and eradication efforts, and 3) better managing established populations of FF. The CLIMEX potential distribution models and analysis of interception data inform the pre-border risks. E-Traps were combined with an automated alert system to send emails to NPPOs to advise of the detection of suspected exotic FF. Real-time climate suitability forecasts (CLIMEX weekly Growth Index) combined with e-Trap data provide border surveillance and FF pest managers with an understanding of current issues and emerging challenges or opportunities. Detailed DYMEX process-based population models can be deployed to assist rapid responses to incursions of exotic FF or assist with management of established FF. These models can be used to conduct war games against FF, testing different management strategies (e.g., mass trapping or SIT) under different situations. In addition to the informatics platform, we developed a system to inform the optimized deployment of FF traps, including an app to allow users to specify an area in which they wish to deploy traps and the number of traps they want to deploy. The app then applies a selected algorithm to suggest where the traps should be placed. The near-complete FF DS-Alert system was presented to stakeholders in late 2023 and was well received. It is presently being commercialized by CERVANTES and UTH, with pilot areas in northern Greece and Catalunya, Spain.

The FF-IPM project developed a list of tools relevant for pre-, at- and post-border management of the three target species

that can be considered as models for other groups of invasive pests. The pre-border tools include the dynamics CLIMEX models for potential distribution, analysis of pathway risks for incursion, trade risk maps and table for resource countries. At- and post-border relevant tools include (a) spatio-temporal maps of population growing conditions, high-risk sites and surveillance trapping, (b) automated alert system, (c) population dynamics models predicting growth at different spatial scales, (d) the kobo fly system for collecting trapping data, (d) web mapping system for regional surveillance. In addition, extended pilot testing was conducted in four countries (Croatia, Greece, Israel, South Africa) to test project generated tools to refine detection efforts. A tool to support trap-deployment, The Fruit Fly Surveillance Trap Deployment Support Tool (FF-STD) has been developed and become available.

The project developed a system of novel IPM approach and advanced modelling tools that will jointly enable more effective medfly control and facilitate replacement of synthetic pesticides with pesticide-free methods - a goal which in practice is not achievable within the conceptual framework of the classic IPM paradigm. The DSS toolbox developed consists of two components: (1) the PESTonFARM modelling platform that simulates development of large cohorts of individual insects operating on a farm, and (2) the Virtual-Farm segment that contains digital representation of the client farm and has an interface that allows to specify various IPM queries and combinations. It simulates lifetime development (from egg to adult), dispersal and fate of individual *C. capitata* females dwelling on the farm according to the local farm topography, site-typical weather patterns, fruit distribution and phenology, and a combination of IPM treatments. The DSS generates a comprehensive set of results of simulated IPM scenarios that are formulated in a standardized

The FF-IPM strategies present a promising contribution towards achieving EU pesticide reduction goals, with a potential decrease in pesticide use of 1500 tons per year among the most infested countries.

user-friendly format. Extensive simulations were carried out using the developed DSS toolbox to elucidate the key mechanisms underlying the IPM process, its drivers, and factors contributing to discrepancies in researchers' and farmers' perceptions of IPM success. The impact of climatic gradients along the medfly presence in Europe on the relative role and performance of management components in the OFF- and ON- seasons were also assessed. The simulations revealed the reasons for the fallacy of the classical IPM paradigm when applied to the management of fruit flies of tropical origin (e.g. ignoring the capacity of the tropical FF for cryptic spring population increase), and showed *C. capitata* management should start in early spring (OFF-Season), before it can even be detected in monitoring traps, focus on the earliest fruits even if not infested noticeably, and then gradually continue to protect subsequent fruits according to their phenology. Used in this way, biological methods can work effectively and substitute synthetic pesticides. The OFF-Season concept and DSS-generated IPM scenarios empirically assessed on 15 fruit growers' farms in 2022 and 2023. A set of optional OFF- and ON-season IPM scenarios were designed and in silico generated using the VirtualFarm DSS. The results positively validated the postulated OFF-Season paradigm shift and confirmed the practical value of



the developed DSS system and its in silico generated IPM scenarios. Strategic guidelines for the OFF-Season IPM are formulated. The developed and on-farm validated OFF-Season medfly management paradigm and the PESTonFARM and Virtual-Farm platform for in silico generation of locally adjusted IPM scenarios jointly constitute a technically sound, interesting and competitive offer to both international R&D community and to the eco-oriented and organic fruit producers in Europe. A very comprehensive assessment was prepared, projecting the socio-economic and environmental impacts of fruit flies and the *C. capitata* management strategies developed. The analysis shows that about 950.000 ha are at risk of serious damage from medfly representing 19 million tons and 8.7 billion euros. The FF-IPM strategies present a promising contribution towards achieving EU pesticide reduction goals, with a potential decrease in pesticide use of 1500 tons per year among the most infested countries. Over a 10-year projection, this would lead to societal savings of almost 53 million euros annually. This underscores the role of FF-IPM as a cost-effective, environmentally sustainable solution to medfly control, offering long-term advantages such as reduced pesticide dependence and enhanced ecological well-being.



A new web-linked end-user-friendly infrastructure, the FF Management Platform was built.

During the framework of the project in the first task, a new web-linked end-user-friendly infrastructure, the FF Management Platform was built. This platform ensures broad and lasting stakeholder access to the new knowledge generated, and tools, products, technologies and services developed (<https://platform.fruitflies-ipm.eu>). It aspires to be a comprehensive solution for informing industry professionals on the one hand, and a first grouping of services for future commercialization on the other. This user-friendly platform is structured into 6 menus: Tools (Technical description of FF-IPM-developed tools), Services (Technical description of FF-IPM-developed experts services), Training modules (Customized training modules for key target stakeholder groups), Pilot testing (Case-study examples and generic operational scenarios), Project publications (Copies of project publications, all published in open access format), Relative research data (Copies of project research articles). A comprehensive strategy to exploit the project products has been followed with a generic exploitation plan and specific business plans for targeted products. A TRL evaluation for all products/services (DSS-Virtual-Farm based advisory services, DSS-Alert based advisory services, Entomopathogenic nematodes, Entomopathogenic fungi, McPhail e-Trap, Delta e-trap, e-Nose, Molecular ID, Pest ID & origin tracing, FF Management Platform) was made and first specific Business plans were individually developed with each partner for these products/services.

Throughout the grant period, the FF-IPM focused on effective dissemination and communication strategies to engage stakeholders and target audiences. By planning

and implementing dissemination activities, making use of available communication tools and coordinating the involvement of partners, FF-IPM achieved commitment to the project's results and outcomes. Dissemination objectives and indicators were set during the initial stage of the project to measure the success of the activities. The project successfully achieved the majority of its dissemination objectives and in certain cases surpassed expectations, using various channels such as social media, webinars, events, newsletters, publications etc. The FF-IPM has made significant progress in contributing to the scientific community knowledge (>30 peer reviewed papers, >50 presentations in scientific meeting. In addition, the 6 webinars organized attracted 574 webinar participants and 1940 viewers via social media uploads. Website analytics show strong online activity with 16,056 users and 15,385 page views, while a mailing list of 1450 contacts and a 1000+ member stakeholder database facilitated effective communication. Social media engagement exceeded expectations with 2403 followers/likes. The FF-IPM project's commitment to increasing knowledge and expertise in fruit fly management was further demonstrated by the development of 25 comprehensive training modules tailored to the needs of different stakeholders. External events, stakeholder meetings and workshops attracted 1200+ participants and fostered further engagement. Lastly, 10 newsletters, 11 tailored policy briefings, infographics, a promotional video, the layman's report (D8.5) and interviews completed the targeted communication and dissemination actions of the project. It is important to note that these activities are ongoing, with additional papers and outputs in progress or submitted, ensuring

The project successfully achieved the majority of its dissemination objectives and in certain cases surpassed expectations.

that some objectives will be achieved even after the project ends. Every one of the FF-IPM dissemination activities have played an important role in raising awareness, generating interest, and fostering collaboration among relevant target groups and stakeholders and FF-IPM partnership is committed to continue to disseminate the project's results and maximizing impact in addressing fruit fly challenges.

Last but not least the project established a fruit fly research community in Europe and contributed to training a large number of young scientists (e.g. post-doctorate research associates, PhD and masters students), and advanced the technical and conceptual capacities of several laboratories in state of the art methodologies and approaches.

Although the FF-IPM project ended, we are committed on keeping its spirit alive and continue disseminating outputs that are in the pipeline. The webpage of the project will remain active for years to come as well as the FF-IPM platform to support stakeholders needs on demand. In addition, we continue to promote adoption and use of our products and several SMEs contribute to marketing some of them (e.g. Cervantes, inSilico IPM). So, the project will remain alive and you will hear from us more in the next few years.



Pia Addison (SU, right) and Aruna Manrakhan (CRI, left) introducing the workshop

Training workshop on fruit fly identification

The FF-IPM training workshop on fruit fly identification was successfully held from November 20 to 24, 2023, in South Africa. The event was organized by Stellenbosch University (SU) in collaboration with Citrus Research International (CRI) and the Royal Museum for Central Africa (RMCA) and took place in the premises of the SU.

The aim of the workshop was to present to the participants interception and detection tools developed within the FF-IPM project and to train them on using the FF-IPM mobile app for the morpho ID of fruit flies.

Among the participants NPPO officers, growers and representatives from cooperatives, research institutions specializing in horticultural pests, and companies engaged in the development and sale of pest control products were included. The course, attended by 23 delegates from seven countries, featured both theoretical lectures and hands-on practical sessions.

Workshop on Fruit Fly Prevention & Management

Instructor at this workshop was the researcher Marc De Meyer (RMCA) who presented various interception and detection tools developed within the FF-IPM project, focusing on utilizing the multi-entry keys designed for recognizing larval and adult stages of economically significant fruit flies. The attendees had the opportunity to come into contact with real fruit fly samples, study them under stereoscopes and with the use of applications for mobile phones, to arrive at the identification of the sample.



Marc De Meyer (RMCA) presenting the FF-IPM interception tools



Trainees at hands-on practical during the workshop

A two-day workshop on Fruit Fly Prevention & Management as part of the FF-IPM project, was successfully held on January 31 and February 1, 2024, in Parma, Italy. The event was organized by the project's partners in collaboration with the European Food Safety Authority (EFSA) and hosted by EFSA.

Presentations were integrated into the 119th Plant Health Plenary Meeting, offering an exceptional platform to showcase the project's products and tools to numerous EU representatives.

This workshop was a unique opportunity to focus on the latest advancements in Fruit Fly Management, bringing together experts and stakeholders from various fields. Presentation of different detection and identification tools was combined with demonstration and use of the different tools. The hands-on sessions provided to approximately 20 delegates from EFSA, the local Italian Plant Protection Agency and University of Bologna students.



4 Workshop's instructors together with EFSA representatives



Marc De Meyer (RMCA) presenting the FF-IPM identification mobile apps



Trainees at hands-on practical during the workshop

Instructors at the workshop were researchers Prof. Nikos Papadopoulos (University of Thessaly, Project coordinator), Marc De Meyer (Project's Technical Manager, Africa Museum) and Prof. Andrea Sciarretta (University of Molise) who presented the different parts of the workshop.

The first day was dedicated to taxonomy and identification of the fruit flies. The attendees had the opportunity to learn how to use the FF-IPM mobile app for the morpho ID of fruit flies. They came into contact with real fruit fly samples, studied them under stereoscopes and with the use of the applications, arrived at the identification of the sample.



Andrea Sciarretta (UNIMOL) presenting the electronic trap for detection and remote identification through learning algorithm



Nikos Papadopoulos (UTH) presenting the management and detection methods of fruit fly populations

In the second day, management and detection methods of fruit fly populations were presented while the use of a delta type of electronic trap for detection and remote identification through learning algorithm was demonstrated.

It was a great opportunity to engage in insightful conversations on the challenges and opportunities in Fruit Fly Management and reflect on the progress made and discuss the future of FF-IPM tools.

Workshop “The PESTonFARM platform and its applications under the virtual farm concept”

The workshop “The PESTonFARM platform and its applications under the virtual farm concept” concerning the virtual-farm concept and PESTonFARM modelling approach was successfully held on November 19, 2024, in Dossenheim/Heidelberg, Germany. The event was organized by inSilico-IPM in collaboration with the University of Thessaly (UTH).

The aim of the workshop was to present and introduce to the participants the newly developed PESTonFARM model and the virtual-farm concept and discuss with them probable applications of the model. Among the participants researchers of Universities and Institutes were included.

Instructor at this workshop was the researcher Slawomir Lux (inSilico-IPM) who presented the approach of virtual-farm concept and PESTonFARM model. Specifically, he outlined the biological processes simulated by the model and gave an overview of platform structure and auxiliary applications supporting farm characterization, simulation process, service provision and data exchange. For better understanding, he presented some case studies and gave examples of the model applications. The attendees had the opportunity to learn about this new tool and understand the range of its use.



Slawomir Lux (inSilico-IPM) presenting the PESTonFARM modelling approach



Slawomir Lux (inSilico-IPM) outlined the biological processes simulated by the model



Discussion on the workshop



Discussion on the workshop

Publications

New articles have been published during the last months in the framework of the FF-IPM Project.

1

Management of the Mediterranean fruit fly, *Ceratitis capitata*: past, present, and future.

JOURNAL NAME
Entomologia Generalis

AUTHORS
G. GIUNTI, G. BENELLI, O. CAMPOLO, A. CANALE,
A. KAPRANAS, P. LIEDO, M. DE MEYER, D.
NESTEL, L. RUIU, F. SCOLARI, X. WANG AND N. T.
PAPADOPOULOS

ABSTRACT
Population monitoring and management of the Mediterranean fruit fly (medfly), *Ceratitis capitata* (Diptera: Tephritidae), are still challenging, and are tightly connected to a deep understanding of its biology and ecology. Within this framework, new innovative control approaches and tools are frequently proposed and developed to integrate the available techniques and to overcome the difficulties involved in designing effective Integrated Pest Management programs. Indeed, some biological, ecological, and genetic characteristics of *C. capitata* can limit the efficacy of classical pest management strategies. This article provides a comprehensive review of the currently available tools, devices and approaches used to monitor and control medfly populations worldwide.

R^G

Read the article [HERE](#)

2

Biology, ecology and invasiveness of the Mediterranean fruit fly, *Ceratitis capitata*: a review.

JOURNAL NAME
Entomologia Generalis

AUTHORS
G. GIUNTI, G. BENELLI, O.
CAMPOLO, A. CANALE, A.
KAPRANAS, P. LIEDO, M. DE
MEYER, D. NESTEL, L. RUIU, F.
SCOLARI, X. WANG AND N. T.
PAPADOPOULOS

ABSTRACT
The Mediterranean fruit fly (medfly), *Ceratitis capitata*, is a highly polyphagous pest that is economically important for fruit production in tropical, subtropical and temperate regions. It is considered a cosmopolitan pest due to its extreme invasiveness and has established populations in all continents except Antarctica. The medfly's broad range of host plants and distinctive biological, behavioral, and genetic traits help it easily adapt to and colonize novel environments. This review provides an overview of the specific characteristics of this species and its current distribution and invasiveness. It also outlines future challenges for medfly bioecology and invasiveness.

R^G

Read the article [HERE](#)

3

Latitudinal variation in survival and immature development of *Ceratitis capitata* populations reared in two key overwintering hosts.

JOURNAL NAME
Scientific reports

AUTHORS
G. D. PAPADOGIORGOU, A. G. PAPADOPOULOS, C. A. MORAITI, E. VERYKOUKI AND N. T. PAPADOPOULOS

ABSTRACT

Ceratitis capitata, a major agricultural pest, is currently expanding its geographic distribution to northern, temperate areas of Europe. Its seasonal biology and invasion success depend on temperature, humidity and host availability. In warmer coastal Mediterranean regions and cooler temperature areas, bitter oranges and apples serve as overwintering hosts during the larval stage. We assessed the overwintering capacity of *C. capitata* populations obtained from different areas of the northern hemisphere by studying the survival and development

rates of immature stages in both fruits under laboratory conditions. Eggs from each population were artificially inserted in the flesh of the two hosts and kept at 15, 20, or 25 °C until pupation and adult emergence. Climatic analysis of the area of the population origin showed combined effects of latitude, host and macroclimatic variables on immature survival and development rates. Egg to adult survival rates and developmental duration were longer in apples than in bitter oranges. For populations originated from southern-warmer areas, egg to adult developmental duration was prolonged and adult emergence reduced at 15 °C compared to those populations obtained from northern regions. Our findings reveal varying plastic responses of medfly populations to different overwintering hosts and temperatures highlighting the differential overwintering potential as larvae within fruits. This study contributes towards better understanding the medfly invasion dynamics in temperate areas of Northern Europe and other parts of the globe with similar climates.

Read the article [HERE](#)

scientific reports

4

Compatibility of soil application of *Metarhizium brunneum* and cover crops against *Ceratitis capitata* soil-dwelling stages.

JOURNAL NAME
Journal of Pest Science

AUTHORS
J. CRUZ-MIRALLES, I. GARRIDO-JURADO, M. YOUSEF-YOUSEF, M. V. IBÁÑEZ-GUAL, Ó. DEMBILIO, E. QUESADA-MORAGA AND J. A. JAQUES

ABSTRACT

Fruit fly ground-dwelling stages (late third instar larvae, pupae, and teneral adults) are susceptible to predation from generalist ground-dwelling predators and to infection by entomopathogenic fungi (EPF). The effect of predators can be enhanced with cover crops and that of EPF by augmentative releases. However, whether these two biological control methods could be combined has not been studied under field conditions yet. Here, we studied in the field whether the enhanced activity of predators against the medfly,

Ceratitis capitata, already observed in a *Lolium arundinaceum* ground cover could be impaired by a soil application of *Metarhizium brunneum*. Our results show that *C. capitata* adult emergence was reduced by this EPF for up to three months after fungal application, with the combination of the cover and *M. brunneum* being the most effective at reducing *C. capitata* emergence relative to bare soil (92.5% reduction). Although *M. brunneum* reduced the activity density of ground-dwelling predatory beetles up to 93 days after application, it showed no clear negative effects on earwigs, no effects on spiders, and a positive effect on ants up to 65 days after application. Therefore, the combined use of a ground cover of *L. arundinaceum* and *M. brunneum* against the soil-dwelling stages of *C. capitata* seems to work synergistically and appears as a strong and sustainable control tactic against the medfly and other fruit orchard pests.

Read the article [HERE](#)

SPRINGER LINK

As we are approaching the project's closure, it's crucial to highlight the various ways we capitalized on opportunities throughout the FF-IPM project duration. Enhancing our communication and dissemination strategies has been essential to ensure maximum outreach and engagement with our target audiences, all of you. Recognizing the significance of remaining connected and responsive to stakeholder needs, we meticulously organized a diverse range of activities, as described below.

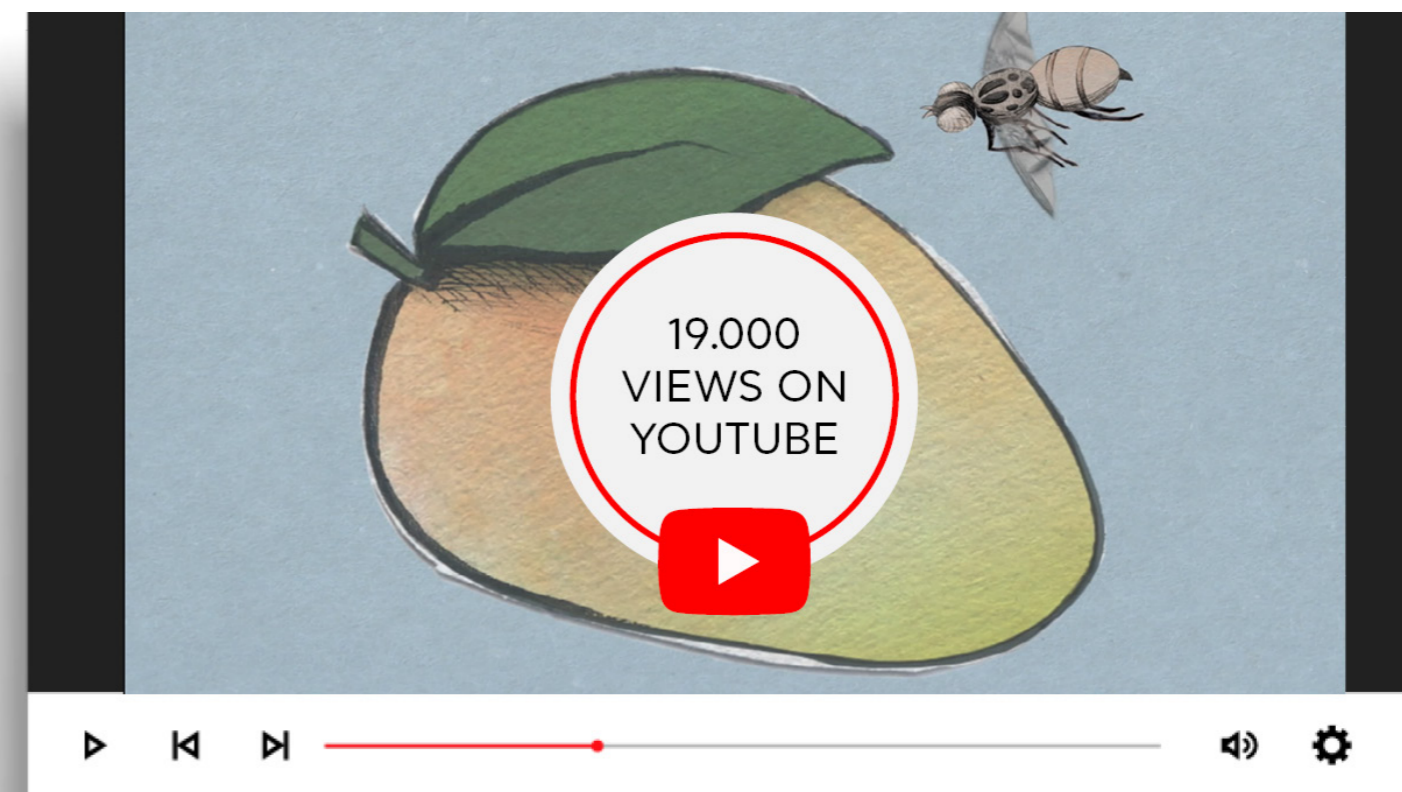


STAKEHOLDER WORKSHOPS

Over 20 stakeholder meetings and workshops were conducted in different countries in addition to the final major stakeholder event.

SCIENTIFIC PUBLICATIONS

More than 20 scientific journal articles in peer review journals were published, while another 10 are submitted for publication.

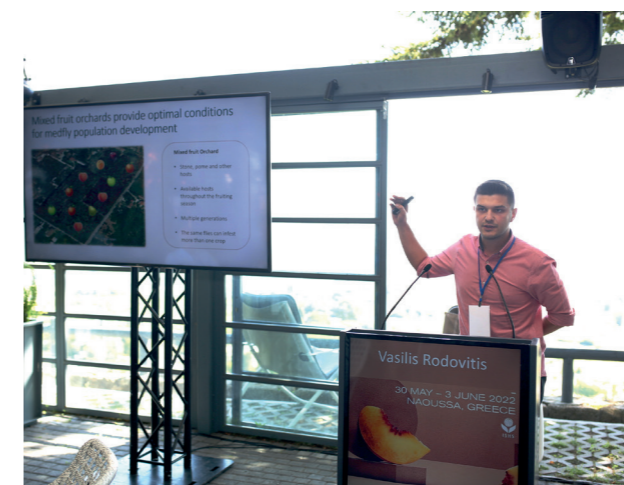


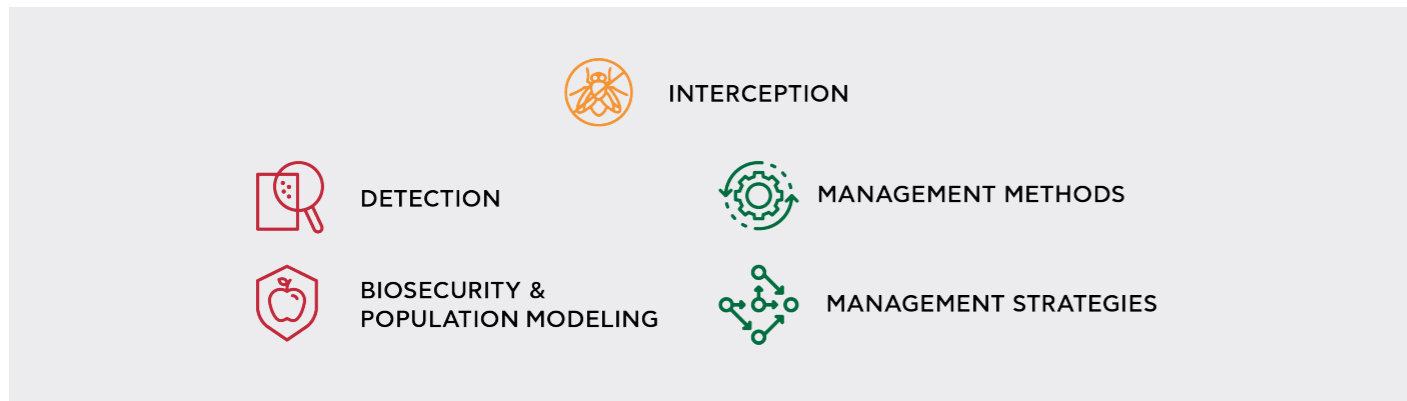
VIDEO

A promotional video was created to visually convey key project messages and achievements, offering scalable and cost-effective communication.

PRESENTATION AT CONFERENCES

More than 20 presentations of FF-IPM took place at national and international conferences, workshops, meetings and other events.





WEBINARS

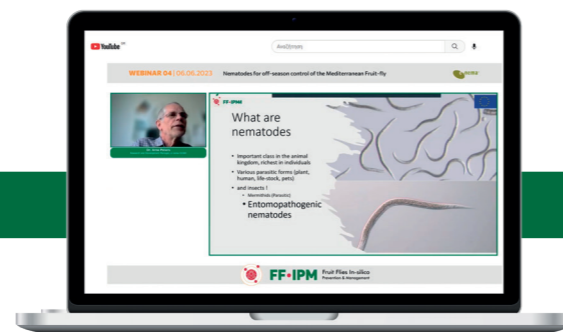
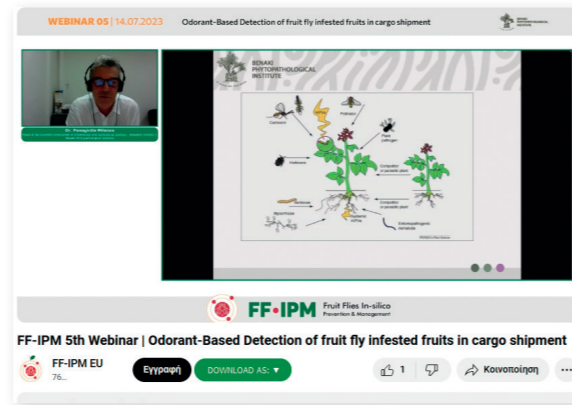
A series of webinars supported and organized by the FF-IPM Consortium were launched since April 2022.

These webinars are related to the FF-IPM project, its scope, deliverables, and scientific suggestions towards an in-silico supported Integrated Pest Management approach for the detection and prevention against new and emerging fruit flies.

TRAINING MODULES

A series of 25 training modules across 5 training entities were developed.

These training materials are used in training events and workshops and uploaded on the FF-IPM platform for continued availability to end-users/ stakeholders.



FF-IPM WEBINARS

536 PARTICIPANTS 1.960 VIEWERS

| | PRESENTER | PARTICIPANTS | VIEWERS |
|--|-----------------------|--------------|---------|
| WEBINAR 01 Fruit Fly detection and interception, the FF-IPM project response | Marc de Meyer | 195 | 547 |
| WEBINAR 02 Smart-trapping & deployment strategy for surveillance of invasive fruit flies | David Nestel | 160 | 400 |
| WEBINAR 03 Modelling the population dynamics of Oriental Fruit Fly, <i>Bactrocera dorsalis</i> : Progress and prospects for a real-time fruit fly forecasting system | Darren Kriticos | 70 | 250 |
| WEBINAR 04 Nematodes for off-season control of the Mediterranean Fruit-fly | Dr. Arne Peters | 60 | 220 |
| WEBINAR 05 Odorant-Based Detection of fruit fly infested fruits in cargo shipment | Dr Panagiotis Milonas | 51 | 543 |

Invited presentation to Hortgro Science

Marc De Meyer from RMCA was invited by Hortgro Science to present collaborative research activities between RMCA and SU within the FF-IPM framework and other initiatives.

Hortgro Science is a research institution dedicated to benefiting South African fruit growers, particularly in the stone and pome fruit industry. In this framework, it organizes monthly hybrid meetings to update industry stakeholders on new developments. During one such meeting, Marc De Meyer presented the FF-IPM program, engaging with participants both physically present and online.



Marc De Meyer (RMCA) during discussion with participants of the Hortgro Science meeting

Final webinar

In our recent (and final) webinar titled "Fruit Flies' Pre-Border Risk: Linking Pathways and Climate Suitability," held on February 26, 2024, we delved into the intricate dynamics of global trade and its unintended consequences on pest transportation. Presented by Anna Sznyszewska, our discussion journeyed through the phenomenon of globalization, shedding light on how it has inadvertently paved the way for pests like *C. capitata*, *B. dorsalis*, and *B. zonata* to traverse borders into previously unaffected regions.

By analyzing historical trade patterns and fruit fly interception data, we uncovered the underlying pathways facilitating the movement of these pests. Additionally, we explored



detailed climatic data from their origin locations, providing invaluable insights into the evolving spatio-temporal patterns of pest importation into Europe. Armed with this innovative methodology, we are better equipped to proactively manage pest risks, illuminating the complexities of pest movement and the inherent challenges it poses to our agricultural ecosystems. *sk: Linking Pathways and Climate Suitability for Fruit Flies.*

Stakeholders meeting in Reunion Island

A stakeholders meeting was successfully held on November 2023, in Reunion Island.

The event was organized by the CIRAD institute. In the event, a presentation of the FF-IPM project was made and some results of the project were presented regarding the tools developed in the framework of the project, by H. Delatte. There were representatives

of growers (mango producers), researchers from the technical institute ARMEFLHOR, CIRAD, the regional chamber of agriculture and the regional Ministry of Agriculture and Food sovereignty subsection linked to plant protection services.

Stakeholders meeting in Volos

A stakeholders meeting was successfully held on February 29, 2024, in Volos. The event was organized by the University of Thessaly (UTH).

This collaborative event brought together key stakeholders from diverse sectors to engage in fruitful discussions and strategize on important matters pertaining to our shared objectives. With UTH's commitment to fostering

collaboration and knowledge exchange, the meeting served as a pivotal platform for enhancing synergies and advancing initiatives aimed at driving positive change within our community.

Upcoming Events

XX International Plant Protection Congress will be held on July 1-5, 2024, in Athens, Greece:
ippcathens2024.gr

XXVII International Congress of Entomology will be held on August 25-30, 2024, in Kyoto, Japan:
<https://ice2024.org/>

European Researchers Night Shines Spotlight on Innovative Insect Trapping Methods

In a captivating evening at Prokurative, Split, the European Researchers Night event showcased groundbreaking advancements in insect trapping methods. Hosted by the EU HORIZONT 2020 MSCA project Blue-Connect, attendees were treated to a presentation titled "How to Catch an Insect," featuring esteemed speakers and demonstrators from UNIST. Mario Bjeliš, Ivan Tavra, Ana Romana Armanda, Gabriela Bartulin, and Krešimir Roguljić unveiled various trapping systems, including the innovative E-trap developed as part of the FF-IPM project. The interactive session engaged 25 participants in games and demonstrations, shedding light on the tracking of the Mediterranean fruit fly (*Ceratitis capitata*) and its impact on ecosystems.



CEKOM 3LJ Final Conference Highlights Successes in Combating Mediterranean Fruit Fly

The town of Trilj became a focal point for discussions on pest management during the CEKOM 3LJ Final Conference. With a turnout of 95 participants from esteemed institutions and local governments, Prof. Mario Bjeliš of UNIST presented findings from the FF IPM project. Addressing the spread of the Mediterranean

fruit fly across Split Dalmatia and Šibenik-Knin counties, Prof. Bjeliš emphasized the project's achievements in monitoring and controlling this invasive species. The unveiling of the E-traps as a promising detection tool marked a significant milestone in the fight against agricultural pests.

66th Croatian Plant Protection Society Meeting Explores Climate Change Impacts on Biodiversity

At the 66th Croatian Plant Protection Society Meeting in Opatija, Prof. Mario Bjeliš led a thought-provoking panel discussion on the repercussions of climate change on agricultural crops, forests, and biodiversity. Drawing from the FF IPM project's research, Prof. Bjeliš highlighted the Mediterranean fruit fly's resilience to changing environmental conditions. With over 90 participants engaged



in the discourse, attention was drawn to the evident influence of climate change on the invasion patterns of *Ceratitis capitata* in Split-Dalmatia and Šibenik-Knin counties.

Stakeholders Meeting: Addressing the Invasion of *Ceratitis capitata* in Inland Croatia

In Dugopolje, stakeholders convened to address the pressing issue of the Mediterranean fruit fly invasion in inland areas of Split Dalmatia and Šibenik Knin County. Prof. Mario Bjeliš delivered key insights from the FF IPM project, shedding light on the Medfly's overwintering capacity and the impact of climate change on its proliferation. With 16 participants actively engaged, the meeting underscored the urgency of collaborative efforts in mitigating the threat posed by *Ceratitis capitata* to agricultural ecosystems.



17th Scientific and Professional Consultation Empowers Croatian Fruit Growers with Innovative Solutions

Zagreb, Croatia - On March 6th, 2024, the Croatian Fruit Growing Association hosted the 17th Scientific and Professional Consultation, drawing over 100 participants including international experts. Among the highlights was an invigorating lecture titled "Non-Pesticide Methods in the Cultivation and Storage of Citrus Fruits - An Example of Good Practice," delivered by renowned expert Prof. Mario Bjeliš from UNIST.

During his presentation, Prof. Bjeliš shared groundbreaking insights from the FF IPM project, emphasizing its potential as additional control measures in the National Action Plan for Medfly Suppression. Leveraging results published in scientific journals, Prof. Bjeliš delved into various aspects of pest management. He discussed the Medfly's remarkable overwintering capacity, shedding light on its ability to survive not only as larvae in infested fruits but also as adults and pupae.

Moreover, attendees gained valuable insights into the utilization of entomopathogenic nematodes for Medfly control, a novel approach explored within the framework of the project. Prof. Bjeliš also addressed the pressing issue of climate change and its evident impact on Medfly invasion patterns in interior regions of Split-Dalmatia and Šibenik-Knin counties.

The 17th Scientific and Professional Consultation served as a platform for fruitful discussions and knowledge exchange, reinforcing Croatia's commitment to innovation and excellence in fruit cultivation.