Fruit Flyer

FFIPM Bulletin • ISSUE 03 • October 2021

Horizon 2020
European Union Funding
for Research & Innovation

FF•IPM

Fruit Flies In-silico Prevention & Management
FF•IPM

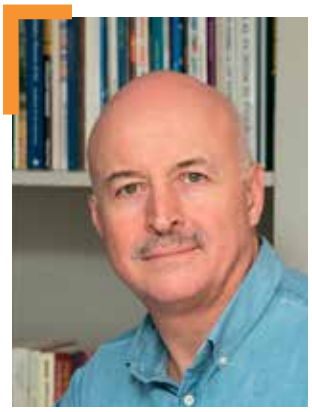
This is the third Newsletter Publication of the EU-funded research project FF-IPM, with the aim to protect fruit production and trade from threats posed by fruit flies.

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

Editor: University of Thessaly

Contributors: FF-IPM partners and experts

Editing & Graphic design: R&DO Ltd



Dr. Nikos T. Papadopoulos, PhD
Professor of Applied Entomology
Director of Entomology + Agricultural Zoology Laboratory
University of Thessaly

FF-IPM Project Manager

There are a lot of interesting developments and progress in the FF-IPM project since January 2021. A major milestone of the project was achieved, namely the submission of the periodic report, and with that the successful evaluation of the performance of our project up to month 18. Despite the hurdles set by the COVID-19 pandemic that affected field and laboratory activities, but mainly the in-person interaction and communication with stakeholders, we concluded a demanding phase of the project that has focused on generating new information, data, tools and methodologies which set the stage for several pilot tests that are planned for the next two years. We are glad that we managed to organize and execute one in-person training regarding fruit fly trapping and the use of electronic trapping devices in July 2021 in Naousa, Greece. David Nestel and Meidad Hoze from the Agricultural Research Organization of Israel joined the University of Thessaly group in this effort that involved a wide range of stakeholders.

Our colleagues from CSIRO and CORVUS GEOSTAT, Darren Kriticos and Ana Szyniszewska, respectively developed and present in the current newsletter a user-friendly tool to collect trapping data from the field. The Kobo-fly will contribute to a robust and timely collection of data, facilitating the instant web mapping which is crucial for decision making regarding response to invasive fruit flies. Hence, "..data collection has never been easier" as Leani Serfontein from the Citrus Research International of South Africa stated following the adoption of the Kobo-fly app.

The FF-IPM dissemination and exploitation platform that was recently launched aims to provide useful information and support stakeholders involved in fruit production and trading

The FF-IPM partner from the Department of Biosecurity at China Agricultural University (led by Zhihong Li) recently demonstrated the use of mitochondrial genome to build the phylogenetic tree of the subgeneric classification of Ceratitis.

Using genome-side SNPs they recovered the four species of the FARQ complex. The paper was published in Molecular Phylogentics and Evolution in April 2021.

Often, policy related issues regarding plant health are not easily digested by researchers performing laboratory and field work on plant protection. However, development, implementation and enforcement of EU legislation and policies are of utmost importance for regional, national and international operations ranging from plant cultivation practices to environmental aspects and trading of Agricultural goods. At the European Union, the institutional and policy architecture of plant health and plant protection is multifaceted and interlinked. Social, economic and human health dimensions should also be included in the above complexity. For example, Directorate-General (DG) for Agriculture, DG SANTE (Health and Food Safety), DG Trade and DG-ENV (Environment), as well as, European institutions such as the European Food Safety Authority (EFSA) and other regional and national plant protection organizations and authorities may be involved. In the current newsletter, Ana Larcher and Uli Schiefer discuss with Wolfgang Reinert, policy officer for plant health at the European Commission (DG SANTE) the above issues. Wolfgang, by bringing the experience of a plant protection scientist, provides a comprehensive overview of the EC structure in plant protection.

As the first two years of the FF-IPM program have been concluded, already novel data, tools, services, and approaches have been generated. Furthermore, the FF-IPM dissemination and exploitation platform that was recently launched aims to provide useful information and support stakeholders involved in fruit production and trading.

Enjoy the 3rd issue
of the FF-IPM Newsletter!

Kobo-Fly: A field data collection system for fruit fly surveillance

Data collected in the field will now be available for web-mapping almost instantly, reducing the amount of time needed to collect, digitise, clean and merge trapping data.

Darren Kriticos, CSIRO
Anna Szyniszewska, CORVUS GEOSTAT

For crop protection, the value of pest surveillance data depends critically upon its timeliness. The lag between trap servicing and digital capture of the data reduces the value of surveillance data for management if the window of opportunity for undertaking pest control has passed.

In Work Package 5 we are capturing data from both conventional traps and e-traps, to map the trap catches in a timely manner across our four main study sites (Fig 1). For the e-traps being developed by Agricultural Research Organization (ARO) and Università degli Studi del Molise (UNIMOL) we are aiming for daily reporting. For the conventional traps we developed a solution to eliminate

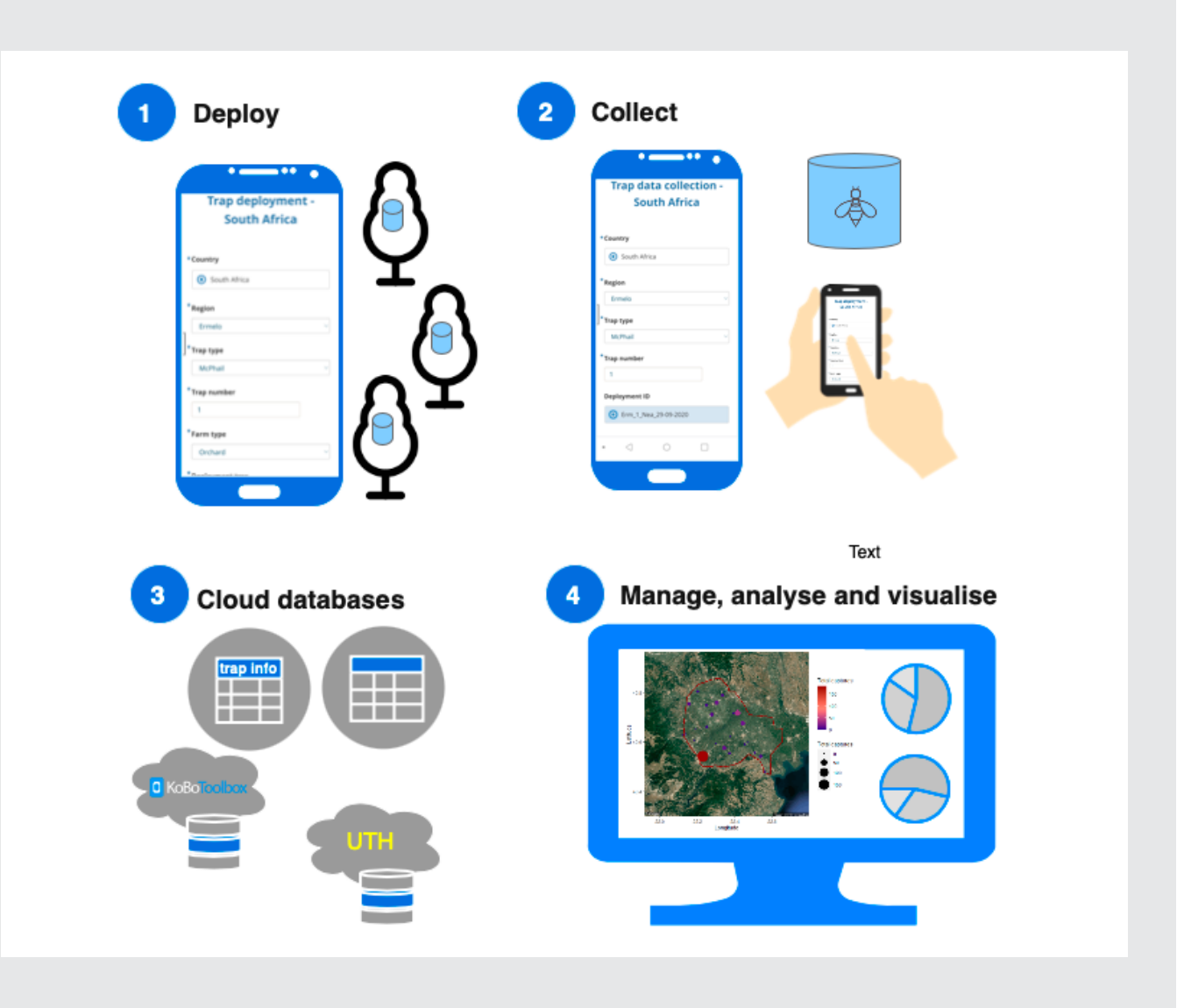


Fig 1. - Kobo-Fly field data collection system

the current time-delay between the trap servicing and web-mapping.

Recently we realised that with four different research partners we had four different systems for collecting the conventional trap catch data, using paper or spreadsheet methods. To process that data ready for web-mapping it needed to be manually reformatted and cleaned to fix typographical errors and inconsistencies and then uploaded into a database. This was a time-consuming and labour-intensive process that introduced significant time-delays into the system. It also relied upon manual error-checking so there were still opportunities for errors to avoid detection. What we needed was an attractive, simple-to-use system to collect the data in a robust, timely manner. As we analysed the situation, we realised that the processes for managing the deployment of the traps also needed to be enhanced to reduce errors.

We explored our technology options. Since this was an unplanned and unbudgeted activity, we needed a solution that we could implement quickly, and was either free, or very cheap to deploy. We wanted a graphical interface that could be deployed on a range of iOS and

Leani Serfontein, Citrus Research International (CRI), using Kobo-Fly to collect field data from a McPhail trap

Android devices that could be used to collect data in a standalone manner and then synchronise with a database when there was suitable internet connectivity. Finally, we wanted the system to work in offline situations where wi-fi or cellular data service are not available, ensuring we do not lose data even if our device loses power. We settled on KoboToolbox as the platform (www.kobotoolbox.org).

Corvus Geostat quickly developed some prototypes and tested them with our field partners (ARO, CRI, UNISPLIT and UTH). Our experience in CSIRO has reinforced how important it is to work with existing workflows if possible, to make the technology as attractive as possible and reduce the friction of adoption. Our philosophy was to make the system mimic the present workflows wherever possible. The time spent consulting the users on their workflows was invaluable. As a result, the UX (User Experience) testing was highly favourable. Within 48 hours the CRI team had entered all their historical data! As Leani Serfontein (CRI) notes, "Kobo toolbox is a great app that saves us time and paperwork. With its user-friendly interface, data capture has never been easier."

We were wary that this type of software development system could end up costing a large amount of valuable project time to develop and refine to get it operational. However, we were happily surprised with how quickly we were able to develop an attractive operational solution. As the main developer from Corvus Geostat, Karol Kozyra, put it in words: "The Kobo-Fly application was relatively easy to develop. The biggest challenge was to harmonise the different workflows across partners. Fortunately, the partners were easy to work with."

Overall, Kobo-fly is a great flexible platform, and the collegiate spirit amongst our partners meant that we could deliver this solution at pace.

Wolfgang Reinert (part 1)

Interview by Ana Larcher Carvalho and Ulrich Schiefer

Wolfgang Reinert, Phd, is Policy Officer for Plant Health at the European Commission in the Directorate-General for Health and Food Safety (DG SANTE).

This Commission department is responsible for EU policy on food safety and health and for monitoring the implementation of related laws.

Wolfgang Reinert studied biology and specialised in ecology and soil biology and worked at the Julius Kühn-Institut – Bundesforschungsinstitut für Kulturpflanzen (JKI) which is the German Federal Research Centre for Cultivated Plants. He got his PhD in the area of microbiology in plant protection for grapevine. He then worked in an institute in plant breeding in Rhineland-Palatinate before he moved to the unit for plant protection in the EC which deals with the assessment and approval for active substances for plant protection products. For the last two years he has been working in the unit on plant health.

In this conversation with Wolfgang Reinert, we had the opportunity to discuss the work of DG SANTE and its links to different structures involved in Plant Health at EU level as well as the connections to other external organizations.

The interview touches upon multiple dimensions including production, the social aspects, economic, trade and health connected to plant health giving an idea of the complexity of the system.

The interview will be published in two parts. In the first part we discuss with Mr. Reinert the work of DG SANTE, the links to DG Agriculture and the links to DG Environment.

THE WORK OF DG SANTE

In the field of plant protection and plant health at the EU level, the institutional and policy architecture is quite complex. You work now within DG SANTE. Could you tell us about the place of DG SANTE within the key institutions that govern plant health at the EU level?

DG SANTE work rests on two pillars – food safety and human and public health. When I started in the unit, which belonged to Directorate-General Health and Consumer Protection (DG SANCO) at the time, we worked on plant protection, plant health and GMOs and seeds. At that time public interest in these areas was not as massive as it is now. Now, these topics have been split amongst three units: Plant Health and Seeds, GMOs, and Plant Protection Products and Biocides.

How does DG SANTE relate to other DG/ organizations within the EU that deal with Food Safety and Plant Protection?

Inside the Commission, there are two strong links, one to the Directorate-General for Agriculture and Rural Development (DG Agriculture) through the agricultural production and the second to Directorate-General for Trade (DG Trade) because what we do is very much trade-related.

So when you look into scientific approaches we often work on similar issues, in pests, animals and plants. In Plant Protection Products, the trade aspect is much weaker and mainly relevant when it comes to maximum residue levels, but not in the products or on the active substances as the legislation does not provide for taking trade issues into account. Plant Health legislation is not entirely under the umbrella of food law and possible disruption of trade play a more important role in the decision making.

Plant Health legislation is not completely under the umbrella of food law. That makes it easier to take trade aspects into account

LINKS TO DG AGRICULTURE

So, do you have strong links to DG Agriculture?

Yes, that is correct. But DG Agriculture does not have the lead in all the areas you would think at first glance. In plant production and plant protection, the only exclusive competency of DG Agriculture is in organic agriculture. But for areas like plant protection, plant health, integrated pest management competencies the lead is with DG SANTE, outside DG Agriculture. So DG Agriculture is very much about policy on agricultural production, it is the Common Agricultural Policy (CAP), the financing of the policy but in a number of aspects food production it is not so much on technical detail, on how things happen in the field.

Do you have a strong connection with the NPPOs?

Yes. We have a network of NPPOs (National Plant Protection Organization) or the national plant protection officers who are in charge of plant health.

This is also strengthened by the Comitology Procedure and the Comitology Process because we discuss

all the legislation there. If the Commission is asked to give an opinion, we either discuss it or at least share our response with the Standing Committee and the Member States communicate with us through the Standing Committee. In the Standing Committee, you have representatives of the NPPOs. And on the level of the Council you also have the group of COPHs, Chief Officers in Plant Health: it is formally a Council working party and there are strong links between the two groups content-wise and institutionally: For some Member States the COPH and the contact point in the Standing Committee may be the same person.

So the COPH could be any person the country nominates as chief officer?

Yes, it is one person that is nominated by the government as director of the NPPO. It may be the head of a unit or a director of a Ministry or the head of an institute; that depends on the structure of each country.

Is there a procedure for the Comitology Process?

The Comitology Procedure is a formal process and laid down in legislation. It is indeed one of the key processes everywhere where you have shared competencies between the Commission and the Council and European Parliament. It leads to a highly intensive exchange of information and very intensive discussions particularly between the Commission and the Member States. We have a standing committee every month, where we sit together for two days in a physical meeting with the Member States to discuss issues. Not all units have as many meetings, but our unit has a lot of routine legislations, so we have a lot to discuss. In plant health you have a lot of tests, a lot of derogation requests from third countries, and a lot of emergency measures, all these go through the comitology procedure. In the field of plant protection products, every approval of an active substance goes through the comitology procedures, as well as every setting up of an MRL (Maximum Residue Level).

In plant health you have a lot of tests, a lot of derogations, and a lot of emergency measures, all these go through the comitology procedure

Would it be the same for the approval of biocontrol methods?

It depends on the method. The legislation on plant production products includes chemicals and semiochemicals, plant extracts and microorganisms. So other methods like control by beneficial invertebrates or mechanical methods are not in the scope of the legislation and they do not need to be approved on the European level. But there is currently an initiative of the Portuguese presidency to request a study from the Commission on the question of whether it would be useful in order to promote the use and accessibility of biocontrol which measures would be appropriate. So the Commission will produce a study analysing the status quo and describing possible actions. And if the study would conclude that the most appropriate solution would be legislation, then we shall start preparing for a legislative proposal on that basis.

Would that fall to your unit?

Such a task is usually directed to the Commission as an institution and the Commission decides which unit will be in the lead. In the case of invertebrate control agents, it was decided that the task shall be attributed to DG SANTE and within that DG, the unit for plant health would be best suited to take on the task instead of, e.g., the unit dealing with pesticides.

So this other unit, on what kind of biocontrol methods do they work?

Semiochemicals which is presumably the biggest business in biocontrol, plant extracts which is a growing business, and microorganisms which is a business with a lot of growth potential. There is in fact a certain overlap with the field of basic substances, as some biopesticides are regulated as basic substances under the pesticide Regulation.

Invertebrate biocontrol agents, basically *arthropods* and *nematodes*, are outside the scope of that legislation and will be the subjects of this study.

Does this mean that any invertebrate biocontrol agent can be introduced into the EU without any regulation?

No: they are not subject to harmonised Union legislation, but there may be national legislation in place. This means that the Member States may or may not have legislation and this is also the background of the study because some Member States are concerned about the introduction or natural spread of invertebrates from neighbouring countries.

Currently, national legislation applies. The subject of the study will be: Does it make sense for harmonised legislation or harmonised standards or not? So it is a very fundamental study that will start from scratch. The decision to tell the Commission to do the study is going to be adopted in the Council meeting soon.

Could you tell us about the links to the work of European Food Safety Authority (EFSA)?

What refers to food, EFSA is not an institution but an agency, and this is another important element in our work. EFSA in its founding act is independent.

EFSA is paid by the Union, but the Union's institutions are is not allowed to instruct EFSA to make a statement in a certain way. EFSA is very keen to defend that independence.

In the area of plant health, the work of EFSA is often complementary to the work of European and Mediterranean Plant Protection Organization (EPPO). In our process, we may use input coming from EFSA, EPPO and also from the Member States. This opens opportunities to look into synergies. Like that, not all the burden is on one pair of shoulders and the overall output will increase.

LINKS TO DIRECTORATE-GENERAL FOR ENVIRONMENT (DG ENVIRONMENT)

DG SANTE also has links with DG Environment. Could you tell us more about how your work in connect?

In the field of plant health there is also an important link with DG Environment. There is legislation on invasive alien species that is not in DG SANTE but in DG Environment because it is linked to biodiversity. They have a unit on biodiversity which deals with invasive alien species. There is a Directive, and they deal with all invasive species, animals and plants, although there is a clear overlap with plant health.

Do they work together with the unit of Plant Health? Is there shared responsibility?

Yes, we obviously have to avoid working in parallel on the same issues.

One recent example would be the brown marmorated stink bug (*Halyomorpha halys*) which caused problems with fruit production but also invaded homes for

a few years in some countries. If such an organism pops up, the Commission has to decide which DG should be in charge and whether it goes to one DG or the other or if there are mixed competencies and we have to define which aspect is considered by which DG.

In that case, what was the decision?

It was mixed competencies. The stink bug does not fulfil the legal criteria for an invasive alien species nor for a quarantine pest, but still, it caused problems to farmers and citizens and Parliamentary questions or letters from citizens came in and needed to be dealt with. But the Commission could provide some money for the farmers, more precisely showing ways for some Member States how to reimburse farmers for their damages.

So DG Agriculture was also involved?

The money came from funds in DG Agriculture. There are funds in DG SANTE as well, but they could not be used in this case, as the stink bug is not a quarantine pest.

If you have a coordinated program implemented by a Member State you need to have an agreement of these three DGs?

Normally not, because you have the principle of collegiality in the Commission, so one DG may only take a decision if the other DGs do not contradict.

This is in order to have funds released for alien pest control?

These funds were released for reimbursing damages. For pest control, the funds we could use are always linked to quarantine pests.

We revise the entry for fruit flies. We have as one category for quarantine pests non-EU tephritidae which is not a very clear issue

So if an organism is not a quarantine pest we cannot spend money on it. That is how the legislation is construed.

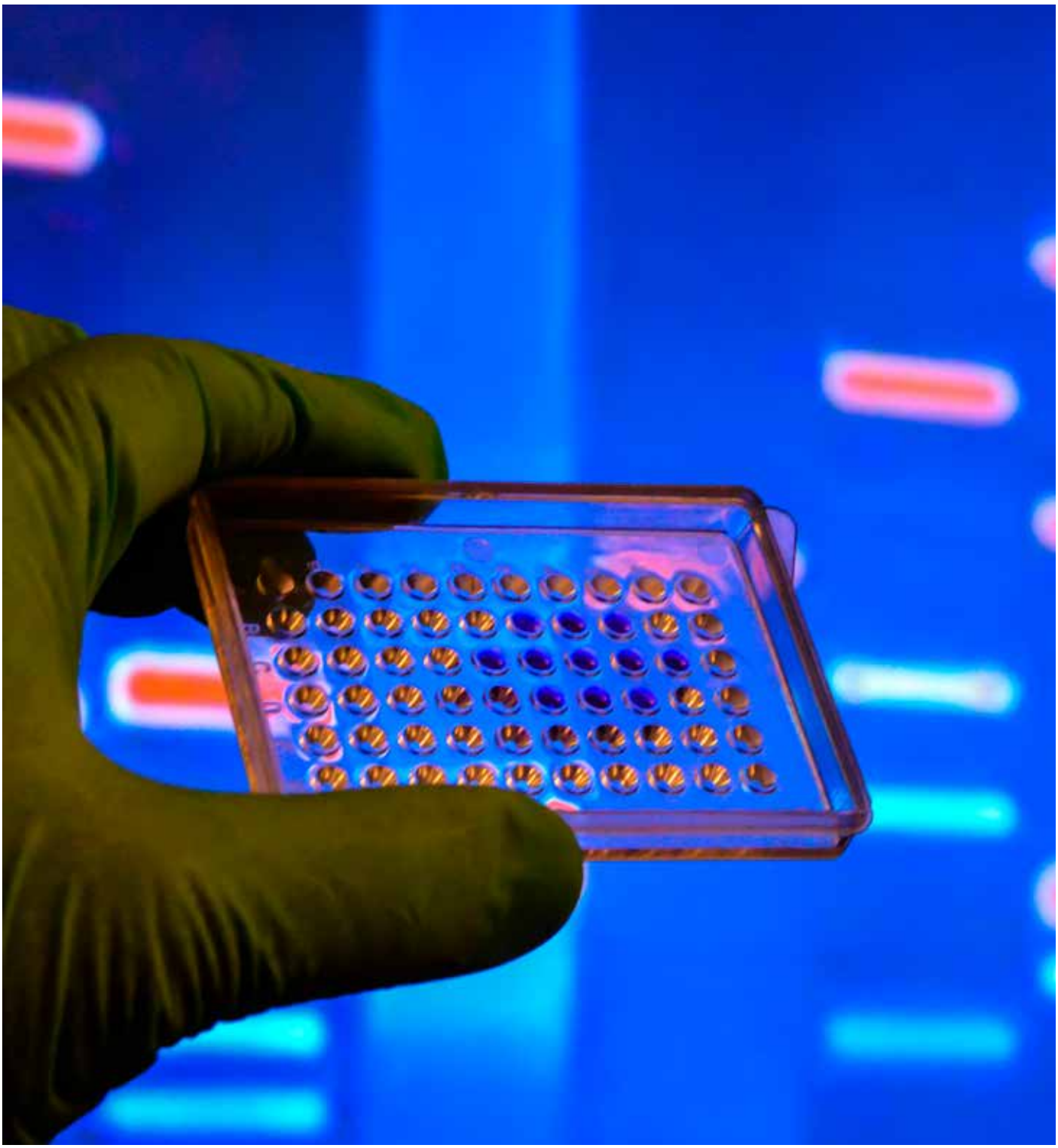
The list of quarantine pests is set by DG Agriculture?

No, it is DG SANTE that draws up the list, it is my unit that prepares the decision. That is in our legislation and we regularly revise that list. In the framework of your project, I would like to mention that we suggest revising the entry for fruit flies. In the current version, only a category 'Non-EU Tephritidae' is mentioned together with an exemplary choice of species, which is not sufficiently clear. Of course, there are species amongst non-EU Tephritidae that do not qualify as quarantine pests because they do not really cause damage. We have made the first revision of that entry and we do name more species. We try as much as possible to name species and also to catch up with developments in taxonomy.

For instance, all references to *Bactrocera invadens* will be changed into references to *Bactrocera dorsalis* now.

The second part will be published in the next issue. Stay informed...

Phylogenomic resolution of the Ceratitis FARQ complex (Diptera: Tephritidae)



This year, important research was concluded by our team members in Department of Plant Biosecurity of China Agricultural University.

The research is on how mitochondrial genomes can help building the phylogenetic tree of the subgeneric classification of Ceratitis to help better recognition and taxonomy.

The Ceratitis FARQ complex (formerly FAR complex) includes four frugivorous tephritids, *Ceratitis fasciventris, C. anonae, C. rosa and C. quilicii*, the latter two causing important agricultural losses in Africa and could infest more than 90 species belonging to 25 families of wild and cultivated plants. Although FARQ species can be identified on the basis of subtle morphological differences, they cannot be resolved as monophyletic when trying phylogenetic tree reconstructions based on mitochondrial or nuclear gene fragments except for microsatellites. Developing accurate, rapid identification tools for species of the Ceratitis FARQ complex would be vital to prevent introductions out of the African distribution of these species. Besides, the subgenus Pterandrus to which the FARQ complex belongs, are divided into two different sections, one of which is paraphyletic to the subgenus Ceratitis s.s. It would now be interesting to clarify further evolutionary relationships between FARQ taxa in the context of the subgeneric classification of Ceratitis.

In this study, we obtained 36 complete mitochondrial genomes from 13 species belonging to four subgenera of Ceratitis to construct the phylogenetic tree. The analysis of 13 species supported the monophyly of the Ceratitis subgenera Ceratitis, Ceratalaspis, Pardalaspis, and recovered Pterandrus as paraphyletic. None of the phylogenetic reconstructions implemented could recover the four morphospecies of the FARQ complex as monophyletic, with most of the supported nodes including mixed samples from different species.

Then we used genome-wide SNPs to investigate the phylogenetic relationship within the complex using Ceratitis capitata as reference genome. Conversely, gene and species tree reconstructions based on 785,484 genome-wide SNPs could allow recovery of the four species of the FARQ complex as distinct and well-supported monophyletic groups and provide insights into their phylogenetic relationships. *C. anonae* and *C. fasciventris* were recovered as sister clades closely associated with *C. rosa*, with *C. quilicii* in a basal position. Gene flow was detected by TreeMix analysis from *C. quilicii* to *C. fasciventris*, suggesting the existence of introgression events in the FARQ complex.

Our results suggest that genome-wide SNPs represent a suitable tool for the molecular diagnosis of FARQ species and could possibly be used to develop rapid diagnostic methods or to trace the origins of intercepted samples. Genome-wide SNPs detected from more representative geographical populations of each species are necessary to further explore the inter- and intraspecific evolutionary relationships within the complex.

Genome-wide SNPs represent a suitable tool for the molecular diagnosis of FARQ species

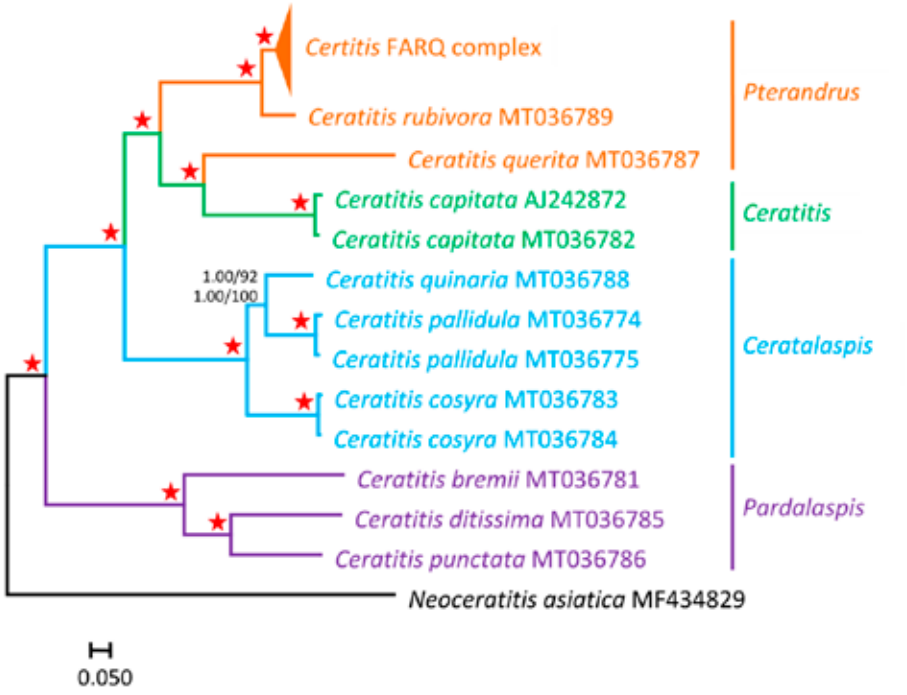


Fig.1 - Maximum likelihood (ML) and Bayesian inference (BI) phylogenetic trees within four subgenera of Ceratitis. Neoceratitis asiatica was used as an outgroup. Values above the nodes represent 1) PCG123 Bayesian posterior probabilities for MrBayes; 2) PCG123 bootstrap values for RAxML; 3) PCG123 and 2 rRNAs Bayesian posterior probabilities for MrBayes; and 4) PCG123 and 2 rRNAs bootstrap values for RAxML. '★' indicates posterior probabilities= 1.00 and ML bootstrap= 100 in all trees.

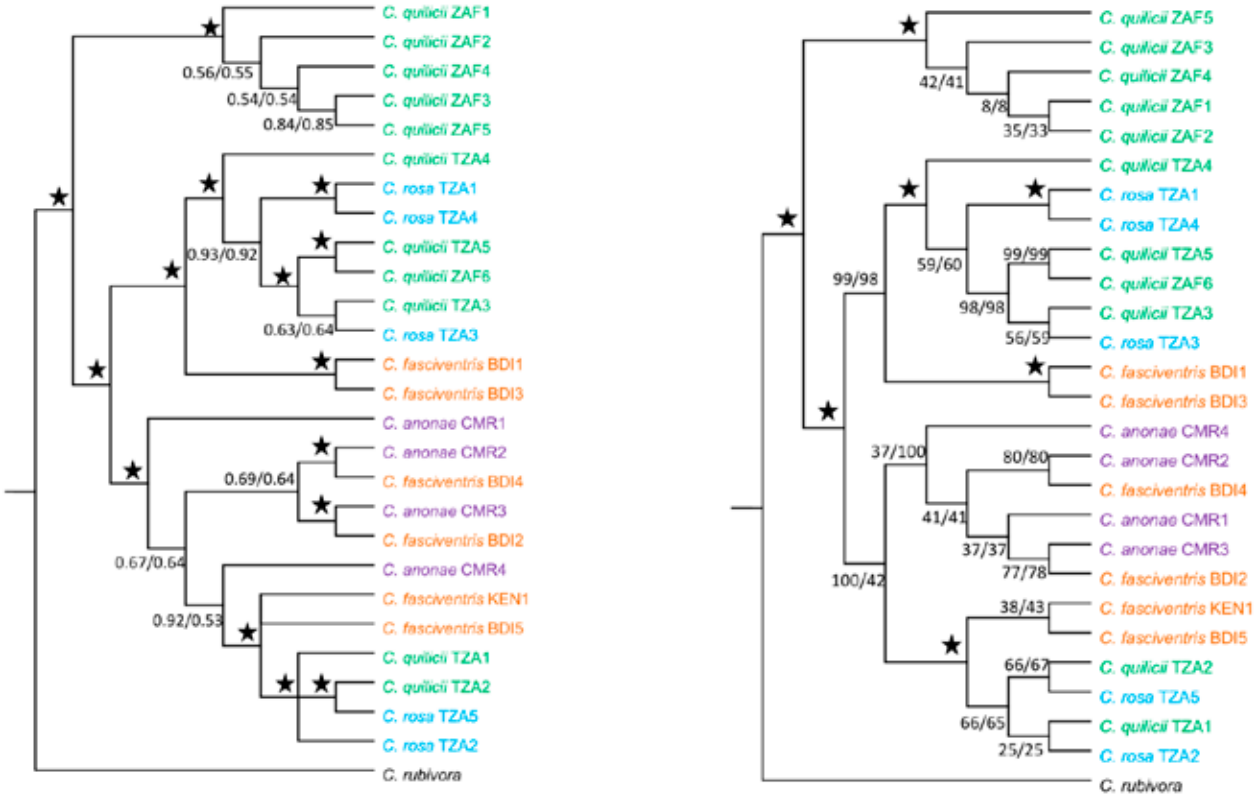


Fig. 2 - Maximum likelihood (ML) and Bayesian inference (BI) phylogenetic trees within the Ceratitis FARQ complex. Ceratitis rubivora was used as an outgroup based on RAxML (Fig. 3A) and MrBayes (Fig. 3B) analysis. Values above the nodes represent bootstrap values for RAxML using dataset 1: PCG123/dataset 2: PCG123 and 2 rRNAs in Fig. 3A; Bayesian posterior probabilities for MrBayes using dataset 1: PCG123/dataset 2: PCG123 and 2 rRNAs in Fig. 3B. '★' indicates posterior probabilities= 1.00 or ML bootstrap= 100 in all trees.

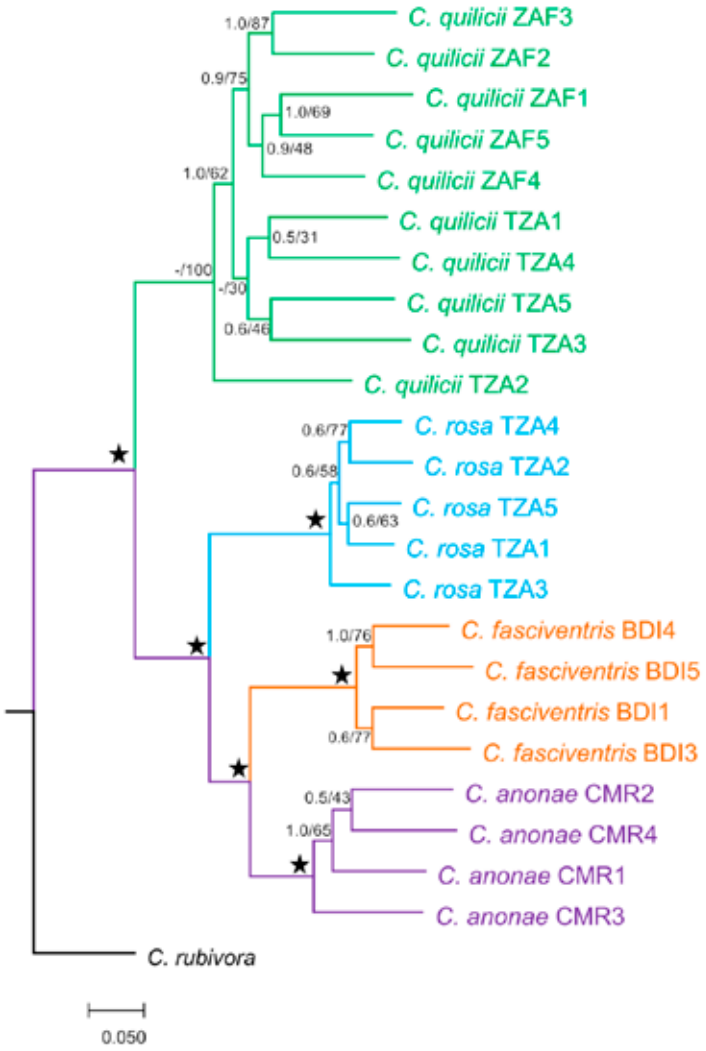


Fig. 3 Maximum likelihood (ML) and Bayesian inference (BI) phylogenetic trees inferred from genome-wide SNPs within the Ceratitis FARQ complex. Ceratitis rubivora was used as an outgroup. Values above the nodes represent Bayesian posterior probabilities for MrBayes/bootstrap values for RAxML. '★' indicates posterior probabilities= 1.00 or ML bootstrap= 100 in both trees. '-' indicates nonsupported.

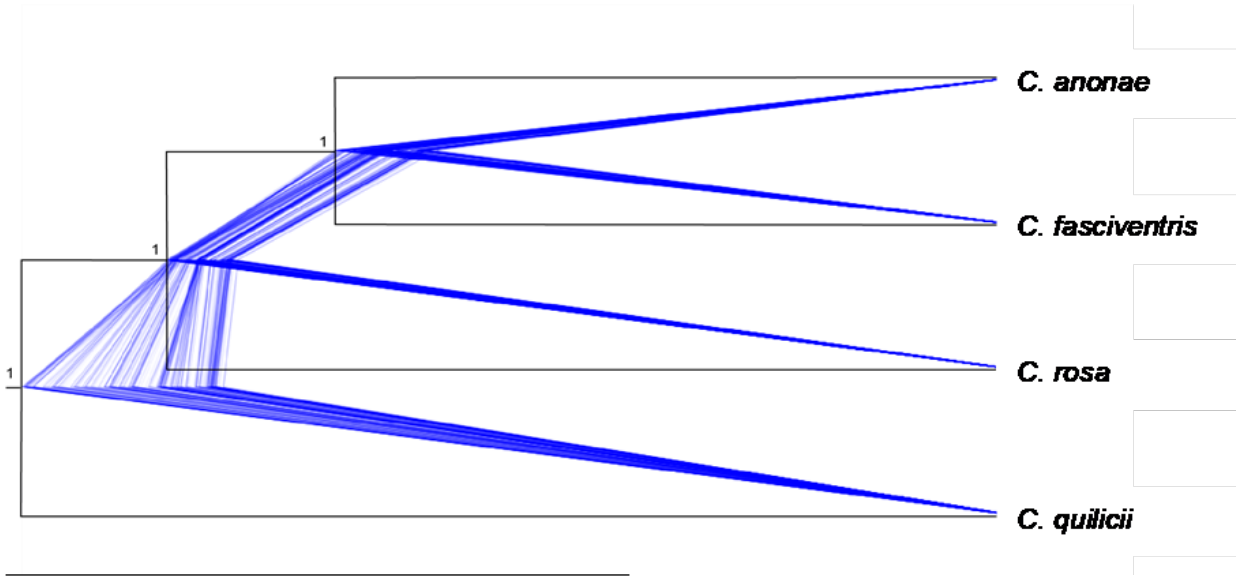


Fig. 4 Species tree estimation of the Ceratitis FARQ complex based on the Multi Species Coalescent Model as inferred by SNAPP and drawn in DensiTree. Support values on the nodes indicate SNAPP posterior probabilities.

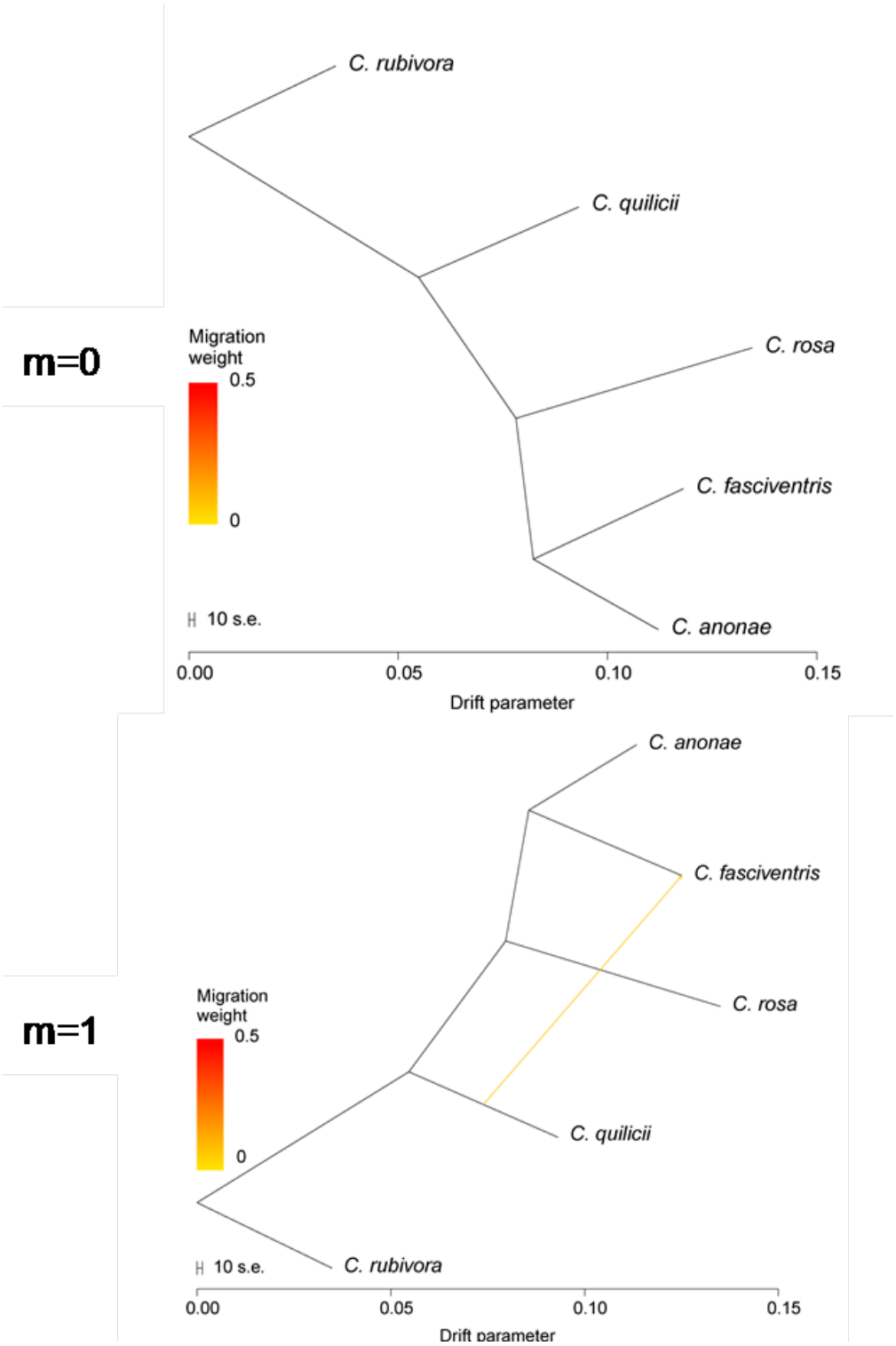


Fig. 5 Phylogenetic network of the genetic relationships among the Ceratitis FARQ complex with different possible migration events (m=0, no migration event; m=1, one migration event) inferred from TreeMix analysis. C. rubivora was used as an outgroup to root the tree. The graph shows the topology and branch lengths according to the drift parameter. Migration arrows were colored according to their weight. The scale bar shows 10 times the average standard error (s.e.) of the entries in the sample covariance matrix W.

Quince production and management according to IPM strategy

The FF-IPM project is intensely interacting with local Greek Quince production towards achieving sound IPM goals.

Every week we are in the field monitoring the conditions related to the growth of the fruit and we test in field conditions the IPM approach in the crop cycle. Our focus is to assist farmers towards reducing and even eliminating pesticide applications.

Our cooperating farmers are enthusiastically supporting the FF-IPM project

Do medflies fly around when raining?

Recent on field inspection of several traps installed by the FFIPM project reveal an impressive activity of adult medflies during a rainy week in the area of Volos, Greece.

Training for e-traps in Naousa, Greece

A team from the FF-IPM project held a successful training workshop in Central Macedonia, Greece. This one-day training took place near the city of Naousa on the 8th of July 2021.

The agents from FF-IPM met different kinds of stakeholders on a prototype farm of fruit trees. Growers, executives with the fruit processing and trading industry, plus students as well.

The purpose of the training workshop was to properly inform the stakeholders about the new species of fruit flies that threaten the crops in Central Macedonia. The region is one of the coldest areas of the country and, as part of the research of FF-IPM has shown, is among the most vulnerable to invasive pests, like tephritid fruit flies.

Another goal was to teach how different traps and trapping techniques work and how one can identify dangerous species of fruit flies and devise the appropriate strategy to deal with them before they cause irreparable damage to crops.

Through detailed lectures in the conference room and the field, we tried to popularize the differences between the existing trapping systems and to explain the importance and innovation of the trapping system developed and used by the FF-IPM project.

The FF-IPM project's e-trap is a "dry type" of trap that has the following advantages:

- It is energy-autonomous
- Uses a built-in micro camera to photograph trapped insects and send their photos to a central database and
- Is monitored twice a day, while the identification of insects is done by specialized software.
- Its deployment allows remote monitoring and identification of harmful insects more easily.

Therefore, the farmer or field manager can quickly and safely diagnose the magnitude of the problem that may exist in the field and minimize the interference time.

The response was enormous, and we are planning on more dedicated training workshops, online and physical presence, in the next months.

FF-IPM and LTZ exchange knowledge on preventing medfly dispersion

Professor Nikolaos T. Papadopoulos, the project manager of FF-IPM, visited the Landwirtschaftliches Technologiezentrum (LTZ) Augustenberg in Karlsruhe Germany from 15 to 17 of September, and met with the scientific committee of LTZ to discuss aspects related with invasive pests in Europe. He presented the concept - approaches of the FF-IPM project and informed LTZ about its latest developments.

LTZ presented its work on other invasive pests like the brown marmorated stink bug (Halyomorpha halys) and discussed with Prof. Papadopoulos possible advances and venues of collaboration on the biology and management of this invasive pest.

In the field of cooperation, LTZ and FF-IPM decided that LTZ could participate in some activities of the FF-IPM regarding medfly dispersal in cooler areas of Europe and share knowledge and expertise with FF-IPM.

PROJECT HIGHLIGHTS

NOV 2020	MAY 2021	JUL 2021	OCT 2021
Trap installation in S.Africa	Testing of OFF-Season application of entomopathogenic fungi in Italy	2nd stakeholders' training series. Naoussa, Greece	2nd Annual meeting

Contribution to research – Summer 2021

FF-IPM within its timespan as a program has set as a specific goal to contribute to further scientific research as much as possible. Within this summer, six important publications have been disseminated.

- Efficacy and residual activity of commercially available entomopathogenic nematode strains for Mediterranean fruitfly control and their ability to infect infested fruits (April 2021). **In Pest Management** Journal, by Kapranas Ap.; Chronopoulou et al.
- Evaluation of Mass Trapping Devices for Early Seasonal Management of Ceratitis Capitata (Diptera: Tephritidae) Populations (May 2021). In **Agronomy** Journal, by Bali E.; Moraiti et al.
- Looking at the big picture: worldwide population structure and range expansion of the cosmopolitan pest Ceratitis capitata (Diptera, Tephritidae) (June 2021). In **Biological Invasions** Journal, by Deschepper P., Terrance et al.
- FruiTemp: Design, Implementation and Analysis for an Open-Source Temperature Logger Applied to Fruit Fly Host Experimentation (June 2021). In **Applied Sciences** Journal, by Bataka E.; Rodovitis et al.
- Phylogenomic resolution of the Ceratitis FARQ complex (Diptera: Tephritidae) (August 2021). In **Molecular Phylogenetics and Evolution** Journal, by Yue Zhang; De Meyer et al.
- Effects of Thermal Acclimation on the Tolerance of Bactrocera zonata (Diptera: Tephritidae) to Hydric Stress (September 2021). In **Frontiers in Physiology** Journal, by Ben-Yosef M.; Verykouki et al.

Fruit Flies In-silico
Prevention & Management
FF•IPM

Horizon 2020
European Union Funding
for Research & Innovation

www.fruitflies-ipm.eu fruitfliesipm H2020Ipm