TO OUR READERS

It is our great pleasure to welcome to the editorial group of the TEAM newsletter Sunday Ekesi (ICIPE, Kenya). The long experience of Sunday and his profession in the heart of Africa will bring more energy and hopefully more news from our African colleagues. Sunday together with Nikos Kouloussis and I will work on enriching our newsletter towards transforming it to a fruit fly magazine. We strongly believe that the TEAM newsletter is one of the most important developments for our group since it brings news to our members and enhances communication. All members of the TEAM steering committee have committed to support the improvement of our newsletter. There are several ideas that we consider and they all depend on your active involvement. A first step would be to include a column highlighting recently defended Ph.D. theses on the field of fruit fly research. In the future we might include Masters Theses as well.

A discussion regarding renewing the composition of the steering committee has opened recently. As we have agreed last year in Majorca we should refresh the steering committee by 2-3/10ths until the next TEAM scientific meeting. Another important issue we discussed recently within the TEAM steering committee concerns the 2nd scientific meeting of TEAM. Our original idea was to hold it in Africa, however, this seems extremely difficult. In fact, for different reasons, neither Kenya nor Morocco can undertake this responsibility. We are now considering alternative options within the Mediterranean area. We keep our original strategy to organize inexpensive meetings. Spring 2012 seems as the most convenient period for organizing the second TEAM meeting.

The current newsletter includes a nice contribution by David Nestel on the spatial dimension of fruit flies populations. David highlights the importance of spatial patterns of fruit fly populations for understanding ecological phenomena, and implementing sound management strategies. Sophisticated technologies have been developed recently, such as the Geographical Information Systems (GIS) and Geostatistics that allow scientists and fruit fly managers to (a) precisely describe spatial patterns of fruit fly populations in the wild, (b) forecast spatial phenomena, and (c) accurately and efficiently implement management procedures. The current paper expertly reviews older and recent studies on fruit flies foraging behavior for various resources in a three dimensional space. Determining spatial patterns is another topic that David covers, providing all recent information of a growing literature on applying geostatistics, and GIS technology to study temporal and spatial patterns of fruit fly populations. Collecting and analyzing fruit fly trapping data has become a widespread activity in several fruit fly management projects the last decade. More recently, spatial analyses of fruit fly populations are being experimentally integrated into spatial decision support systems to manage fruit fly populations. Last but not least, David presents a conceptual model that integrates biological, environmental and spatial information into a decision making process to deal with fruit fly pests.

Finally, I would like to ask you once again to communicate your news and report all your activities to be included in the following TEAM newsletters.

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The Space is the boundless, three-dimensional extent in which objects and events occur and have relative position and direction (definition, from Wikipedia). Hence, the space is the place where living organisms interact between them and with the physical and chemical environment. The physical space is often conceived in three linear dimensions, although modern physicists usually consider space together with time to be part of the boundless four-dimensional continuum known as "spacetime" (from Wikipedia).

The study of the dispersion patterns of organisms in space and time has its value in the understanding of ecological phenomena and for management purposes. The next lower level in the hierarchy (i.e., at the population level) should be sought at the organism level. They propose that mechanisms underlying ecological phenomena expressed at a particular hierarchical level (as an example at the population level) should be sought at the next lower level in the hierarchy (i.e., at the organism level). They propose that mechanisms operating at the level of the individual, and expressed in a patchy environment, produce ecological phenomena that are sensitive to the effects of spatial variation. That is, the individual attributes of the average organism (i.e., physiological state, food choice, habitat selection and movement) concurrently with patch attributes (such as spatial disturbances and spatial patch pattern and dynamics) result in spatial phenomena that are expressed at the population level.

Foraging in Space: Fruit flies require food, mates, oviposition sites and refugia as essential resources (Prokopy et al., 1994). Foraging for these resources in several species of fruit flies is a dynamic process (Hendrichs et al., 1991, Aluja & Birke, 1993, Aluja et al., 1993). Individual flies have been tracked moving between habitats on a daily cycle due to feeding, mating and egg laying requirements. Flies have also been observed to adjust their foraging behavior in response to the changes in the spatial, temporal and seasonal distribution of food resources (Hendrichs et al., 1991).

The spatio-temporal dispersion patterns of a fruit fly population throughout the landscape can be interpreted as a reflection of the summary of foraging behavior of individual adult flies. Daily activities of flies consist of resting, feeding, lek formation, mating, and egg laying (Hendrichs & Hendrichs, 1990, Hendrichs et al., 1991, Warburg & Yuval, 1997). In most cases flies tend to perform all of these activities within a restricted space, composed principally of ripe and unripe host fruit trees, in which they can obtain enough nutrients, shelter and egg-laying hosts (Hendrichs & Hendrichs, 1990, Warburg & Yuval 1997). Thus, dispersion of flies to other places is minimal as long as habitat conditions are appropriate (Fletcher, 1989, Hendrichs & Hendrichs, 1990, Averill & Prokopy, 1993, Prokopy et al., 1994). On the other hand, when habitat conditions deteriorate flies will emigrate and disperse in search of more favorable habitats (Fletcher, 1989).

Intensive pioneer studies on fruit fly foraging behavior were undertaken by the late Prof. Prokopy and his students. Released, and wild, flies were meticulously tracked throughout the environment. Hendrichs & Hendrichs (1990) and Hendrichs et al. (1991) followed wild Mediterranean fruit flies location throughout the day in host and non-hosts trees and orchards in Mediterranean settings and found that movement, and spatial location, was sex related and influenced by temperature and shading, food requirements and availability, and sexual activity. Learning and foraging was also explored in wild Medflies previously exposed to specific hosts and then released into potted trees harboring a choice between pre-exposed hosts and non pre-exposed hosts; flies visited fruit-hosts to which they became familiar in the pre-exposure period at a higher rate than unfamiliar hosts (Prokopy et al., 1989). Other studies followed similar working protocols and explored similar questions in other fruit fly species (e.g., Prokopy & Papaj, 1986; Vargas & Nishida, 1989; Green et al., 1992; Averill & Prokopy, 1993). Within these studies, the one conducted by Martin Aluja for his Ph.D. under the supervision of the late Prof. Prokopy deserves a special mention. Martin established a tridimensional “Euclidean Space” in the canopy of an apple tree by meticulously dividing the tree into imaginary cubes (Aluja, 1989; Aluja & Prokopy, 1993). This Euclidean space was assigned with x-y-z coordinates and Rhagoletis pomonella flies were released in the center of the lower canopy, and their movement and position in space followed under different environmental stimuli. Its study showed that flies under no fruit host or fruit odor moved and forage at random (Casas & Aluja, 1997), while odor and visual stimuli promotes a directional movements.
towards the source (Aluja & Prokopy, 1992; Aluja & prokopy, 1993).

More recent studies on foraging behavior and individual movement and position in space were conducted by Martin Aluja and co-workers on Anastrepha species and its parasitoids, and by Boaz Yuval and co-workers with Medfly. Aluja’s studies mainly investigated the effect of host fruit and habitat on foraging, egg-laying behavior and spatial patterns of flies (see for example, Aluja et al., 1997; Sivinski et al., 1997; Sivinski et al., 2004), while Yuval’s studies concentrated on the physiological state of flies and their foraging and reproductive behavior (Warburg & Yuval, 1997; Yuval et al., 1998).

Being Trapped in Space:
The main tool used to follow and explore population spatial patterns of Tephritidae, and many other insect species, is the trap. In general, active trapping results from providing the traps with an odor and/or visual stimuli that is known, or expected, to attract flies. Trapping, thus, involves observation of the active behavior of the flies and their “willingness” to follow that specific stimulus. In this sense, traps need to compete in the field with other more vital stimuli emanating from the environment, and it is expected that the amount of flies being trapped is a very low proportion of the population and is composed of individuals being in a specific physiological state that made them vulnerable to the attractiveness of the trap. Moreover, due to the ongoing changing environmental condition, the attractiveness of traps is expected to differ in space and time. In spite of all these counts, traps are the main tool to detect and manage fruit flies in agricultural settings, and have been used for many decades.

The oldest, non-digital, papers on fruit fly trapping that I was able to find in my library, and that survived all the environmental harshness of the last 20 years, are those of McPhail from the 1930’s. Like those papers, most of the many papers on fruit fly trapping relate to trap development and testing, use of trap to follow phenological trends and use of traps in monitoring and pest management. As far as I am concerned, few papers explicitly used traps in relation to Tephritidae spatial patterns and the exploration of the environmental determinants of trapping on a geographical space.

During the 1980’s Hawaiian scientists explored the spatial patterns of Ceratitis capitata trapping in the islands to develop strategies to control the Medfly in Hawaii (Vargas & Nishida, 1989). Similarly, some studies explored spatial patterns using trapping as a tool to investigate dispersal and dependence between populations located in arid areas and separated by political barriers (Harris & Olaquigha, 1991). During the mid 1990’s we investigated the spatial patterns of the Medfly in a heterogeneous agricultural setting in the central highlands of Israel (Israely et al., 1997). The study included a very large grid of Steiner traps (loaded with trimeure) spread throughout a relatively small region (2 X 4 km), which included commercial orchards, home-gardens in a human settlement, and Mediterranean shrub and pine forest vegetation. This intensive study showed some interesting spatio-temporal patterns of the flies driven by host-fruit phenology, climatic patterns and agricultural practices (Israely et al., 1997). The study also was one of the first using spatial statistics (specifically, Getis-Ord local spatial statistics; Getis & Ord, 1996) to infer on the spatial patterns of a Tephritidae fruit fly (unpublished results). Using this statistics we were able to infer on significant host spots in space and time, and to relate them to seasonality, host status, climate and management. During the late 1990’s Papadopoulos et al. (2003) systemically followed the spatio-temporal patterns of Medfly captures of male and females in a mixed non-managed agricultural orchard (ca. 2 hectares) composed of deciduous fruits. The trapping patterns were analyzed using geostatistics (specifically, Moran’s I spatial autocorrelation statistics; Clift & Ord, 1981). This study showed that male and female fruit fly express different spatial patterns and that spatial pattern in the orchard were mainly driven by host-phenology and the sequence of fruit ripening. A later study on an olive orchard using McPhail traps loaded with ammonium attractants showed that the olive fly dispersion patterns within an orchard is highly influenced by humidity (during summer) and fruit load in trees (Dimou et al., 2003).

Large geographic scale studies of fruit flies spatio-temporal patterns include the study of Israely et al. (2005), on the Medfly in Central Israel, the study of Duyck et al. (2006), on the climatic partitioning of fruit fly species in the Island of Reunion, and the study of Kounatidis et al. (2008) on the spatio-temporal patterns of the olive fly in Northern Greece. Israely et al. (2005) studied the phenomena of spatial patterns of the Medfly in Israel from the migration perspective, while Duyck et al. (2006) and Kounatidis et al. (2008) investigated the effect of elevation and climate on spatial patterns of fruit flies. Of special interest is the study of Duyck et al. (2006) which analyzed historic trapping data, and larval infestation data, on a large area including different elevations and climatic gradients in an island landscape. Their study showed the cohabitation and niche differentiation of 4 fruit fly species, 3 of which invaded the island on successive events. Their study showed how climatic diversity affects establishment patterns and species displacement. The study of Kounatidis et al. (2008) explores the effects of climate on an altitudinal, climatic, gradient and suggests that olive fly spatial patterns are highly linked to the temperature tolerance range of the fly.

Release-recapture studies have served to investigate the ability to disperse of released insects, and the effects of environmental and biological traits on dispersal ability. These studies have importance in SIT projects, establishment of monitoring systems and surveillance of invasions. Dispersion is usually investigated by using trapping grids and investigating the resulting spatial patterns of released flies. In this field of study, the work conducted by Alfie Meats and colleagues is of special interest. Meats has investigated the release of sterile and non-sterilized fruit flies in Australia, and elegantly modeled their dispersion patterns and dispersion abilities. Thus, as an example, Meats and Smallridge (2007) and Meats and Edgerton (2008) modeled the dispersion patterns of released Medflies and Queensland fruit flies (Bactrocera tryoni), respectively, and found that disper-
sion patterns fitted power, logarithmic and Cauchy models, and were able to estimate median dispersal distances for the two species. They were also able to show differences within species in their dispersion ability that was related to the maturation stage of the flies, and the invading potential of propagules (Meats & Edgerton, 2008). Meats et al. (2006) also applied dispersion theory and models in order to determine the effective range and release plans for sterile flies in SIT projects.

Managing Flies in Space:
Besides providing a tool to study the ecology of fruit flies, spatial analysis is expected to become a tool in fruit fly management. Mapping and digitizing trapping data into Geographic Information Systems (GIS) is a relatively widespread activity now a day in SIT projects. Projects in Argentina, Australia, Guatemala, Mexico, Hawaii, Continental USA, Israel, etc., systematically upload trapping data on wild and sterile insects and damage data to provide navigation guidance in the release of sterile insects, to display the trapping sites and monitoring routes, and to investigate the effect of environmental conditions on trapping, damage and control (Cox & Vreysen, 2005). Spatial analysis has also been used to manage and understand application of other control techniques, such as mass-trapping. As an example, Nestel et al. (2004a) and Nestel et al. (2004b) studied the spatial patterns of Medfly and olive fly respectively using GIS interactively in projects of mass-trapping; in the case of the olive fly, GIS was used to visualize hot-spots of damage and make decision on augmentation efforts in specific areas of the agricultural landscape (Nestel et al., 2004b). In the case of the Medfly, GIS and spatial analysis provided “post-factum” information on the possible causes explaining damage patterns in a space under a mass-trapping regime (Nestel et al., 2004a). Recently, Jang et al. (2008) reported on a large scale, multi-year, area-wide project targeting the melon fly (Bactrocera cucurbitae) in Hawaii in which GIS mapping is used to deploy trapping grids, and to manage the utilization of a battery of control tools (parasitoids, SIT, GF120, etc) to contain the pest. Their efforts and spatial approach successfully contained the damage created by the fly and demonstrated the effectiveness of this approach to manage fruit fly pests.

During the last years, the spatial analysis approach is being experimentally integrated into spatial decision support systems (SDSS) (Cohen A. et al., 2008 and Cohen Y. et al, 2008). Cohen Y. et al. (2008) developed an SDSS for controlling Medfly in citrus (“MedCila”) through the acquisition of relevant expert knowledge, identification of relevant criteria, and modeling criteria over a decision-making procedure, and through the integration of the system into a GIS.
environment. MedCilia was shown to effectively make correct decisions of up to 80%, reducing unnecessary sprayings by an 8% rate, which was estimated to save 13.3 Tons of pesticide and $250,000/year (Cohen A. et al., 2008).

The ideal approach to manage fruit flies in space:

It is my impression that an ideal system to deal with fruit flies (and other pests) in area-wide projects requires the ability to forecast, and react, to potential population increases and risk of pest damages in the spatial and temporal dimensions. That is, a system that will have the ability to develop implicit maps of the agricultural space, where population modeling will suggest the potential for local pest population explosions and for the increase in the risk of damage. Such systems will require feed-in field data to dynamic population models simulating future population and damage trends in a geographic matrix. As a result, implicit maps showing local pest population trends, statistical hot-spots, and risk of damage and probability of contagiousness to neighboring areas could be generated and used to activate decision making systems (see Fig. 1 that schematically describes this ideal system). As far as I am concerned, no such system yet exists to manage fruit flies. Cohen A. et al. (2008) and Cohen Y. et al. (2008) work is a first approximation to this ideal system. Their study also establishes the basis for future developments in this direction, in which past generated knowledge and technologies can be utilized and combined to manage and control fruit flies with a minimal environmental impact and a higher control efficacy.

References


Meats, A. and Smallridge, C.J., 2007. Short- and long-range dispersal of Medfly, Ceratitis capitata (Dipt., Tephritidae),


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PHOTOS FROM AN AWARD

During the first meeting of TEAM (Mallorca, April 2008) the Steering Committee decided to make an award to Jorge Hendrichs for his outstanding contribution to the field of fruit flies and his supported in the establishment of our group. Here is a photo of Jorge and his TEAM receiving the award in the headquarters of FAO/IAEA in Vienna.
Information on the Tephritid Workers Database are now included in Wikipedia: http://en.wikipedia.org/wiki/Tephritid_Workers_Database

The issuing of the old "Fruit Fly News" (FFN) newsletter has been resumed after a long period of interruption (since the early 1990s). This newsletter was edited by Ernst Boller, P. Liedo and others. The new editorial team consists of Abdel Bakri, Pablo Liedo and Olivia Kvedaras. Visit The second May 2009 issue of FFN is already out.

**Nuclear Science Protects Revered Fruit**

IAEA Uses Sterile Insect Technique to Tackle Olive Fruit Fly

**FORTHCOMING MEETINGS**

IOBC/WPRS Working Group “Induced Resistence in Plants Against Insects and Diseases”. 12-16 May 2010, Granada, Spain.


61st International Symposium on Crop Protection. 19 May 2010, Gent, Belgium.


International Congress on Biological Invasions. 2-6 November 2010, Fuzhou, China.