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Invited paper

Biological control on insect pests in citrus orchards in Greece
George J. Stathas, Panagiotis J. Skouras ........................................................................ 1-9

Abstract: Cases of biological control application against insect pests of citrus in Greece are referred. These applications were implemented to control Hemiptera (Homoptera) pests on citrus, such as aphids, whiteflies and scale insects of the families Margarodidae, Diaspididae, Coccidae and Pseudococcidae. The first recorded case of classical biological control is the introduction of Rodolia cardinalis (Mulsant) for controlling the fluted scale Icerya purchasi Maskell between 1910-1913. Later, between the years 1962-1972, five hymenopteran parasitoid species were introduced to control the red scale Aonidiella aurantii (Maskell). Another case of biological control of scale insects was the augmentative release of insectary-reared predator Rhyzobius forestieri Mulsant during 1983-1992, which was used against the soft scales Saissetia oleae (Olivier) and Coccus pseudomagniliarum Kuwana. The predators Cryptolaemus montouzieri Mulsant (in 1970 and 1991-92), Nephus reunioni (Fursh) (in 1970), N. anomus (Mulsant) and N. quadrimaculatus (Herbst) (in 1991-92) were reared massively in insectary and were used against the mealybug Planococcus citri (Risso). The predators Rhyzobius lophanthae Blaisdell and Chilocorus bipustulatus L. were reared and argumentatively released against the armored scale Lepidosaphes gloverii (Packard) during 2001-2003. As far as whiteflies is concerned, Encarsia lahorensis (Howard) and Cales noacki Howard were introduced to control Dialeurodes citri (Ashmead) and Aleurothrixus floccosus (Maskell), respectively. The predator Harmonia axyridis Pallas was introduced from France and was used against aphid pests.

Section I: Ceratitis capitata

Exotic fruit fly detection and response programs in California, USA
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Bactrocera papayae: Lessons in surveillance and eradication of an exotic fruit fly pest from Australia
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Current status of Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) in Turkey
Naime Z. Elekçioglu ................................................................. 15-22

Abstract: The Mediterranean fruit fly (medfly), *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) is one of the most important insect pests of fruit and vegetables worldwide. In Turkey, *C. capitata* has a wide range of host plants, mainly fruits, where citrus is one of the most important. Medfly reduces fruit production and increases insecticide use, and therefore exerts a direct impact on the production cost. The control of the pest is based mainly on insecticide treatments. The use of traps for monitoring the pest population and determining the proper time to spray is important in the control of the pest. In this study the population dynamics of the pest was studied in a Washington navel orange orchard in Adana during 2008-2010. The flight activity of *C. capitata* was studied by using Jackson traps baited with trimedlure. Adult monitoring was conducted throughout the year. No adults were captured during the winter months. Captures started in April-May and reached a peak in June. The availability of other host fruit species in the vicinity of the grove may explain this abundance. There was a second peak in October during citrus fruit ripening period and the maximum catch was 249, 321, 287 flies/trap/week in 2008, 2009 and 2010, respectively at this period. The pest population was higher from mid September till mid November. Besides population dynamics, distribution, host plants and control of the pest in Turkey were discussed.

Influence of environmental factors on the fitness and flight dynamics of the adult fruit fly *Ceratitis capitata* (Wiedemann, 1824) (Diptera: Tephritidae) in a citrus orchard in the central Mitija (Algeria)
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Micro – SIT: a novel control of the Mediterranean fruit fly *Ceratitis capitata* in citrus orchards
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Effects of kaolin in the behaviour of *Ceratitis capitata* on citrus fruits
J. M. Campos Rivela, M. T. Martinez-Ferrer .............................................................. 27-32

Abstract: In this study, we explore the effectiveness of kaolin treatments in protecting fruit from medfly in laboratory tests. Kaolin is a fine-grained aluminosilicate mineral that makes the fruit less suitable for fruit flies oviposition. This study focuses on behavior of medfly on kaolin treated fruits. Orange fruits cv. “Valencia Late” were dipped in a suspension of kaolin. Several doses (1.5%, 2.5%, 3%, 5% and 6%) applied one and two times were tested. Once dried, the color of treated fruit was measured using a Chromameter CR-400 (Minolta, Osaka, Japan). Choice and no-choice experiments were conducted in order to test the kaolin protection against oviposition of *C. capitata*. In all experiments, 20 mated females per fruit were allowed to oviposit for 5 days. Then, fruits were placed individually into small containers to allow larvae to evolve. The number of larvae per fruit was recorded. In addition, the behavioral response by *C. capitata* to kaolin treated citrus fruits was studied. Results are discussed and compared with previous findings.
Determination of an adequate attractant and its concentration in mass-trapping of *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) by a hand-made trap

Hüseyin Başpinar, Yusuf Karsavuran, Nevin Başpinar, Türkan Koçlu, Fulya Kaya Apak, Pınar Güneyi .......................................................... 33-40

Abstract: The objective of this study was to compare the attractive effects of different attractants in different concentrations in mass-trapping of *Ceratitis capitata* by a hand-made trap. The study was conducted in late peach, mandarin and orange orchards in Aydın and İzmir provinces, in 10-15 yr-old orchards. Experiments were done with three replications in randomized complete block design. Traps were produced from transparent plastic bottles of 500 ml volume with 250 ml attractive solution inside. Ammonium acetate and ammonium carbonate solutions were prepared in the concentrations of 2, 5, and 10%. Control traps were filled with 250 ml of water. Another group of traps with Nu-Lure in the concentration of 2% were used in the same volume like others as positive control. Traps were placed in 1.5-2 m height on the branches in south part of the trees right after first *C. capitata* catches on parapheromone traps in the same orchards, and all traps were counted once a week. The parapheromone traps were the most effective in terms of *C. capitata* numbers caught in traps. They were followed by either Nu-Lure or any concentration of ammonium acetate according to orchards and localities. Ammonium carbonate was the least effective in all cases.

Evaluation of ceranock attract and kill and Femilure mass trapping strategies to combat Mediterranean fruit fly, *Ceratitis capitata*, in Tunisia

Nayem Hassan, Sarra Bouagga, Monia B. H. Kamel, Adel Jammazi ...................... 41

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Mass-trapping of *Ceratitis capitata* (Diptera: Tephritidae) in citrus: how it works and factors to improve its efficacy

Andrés Alonso-Muñoz, Ferran Garcia-Marí ........................................................ 43-50

Abstract: The spatial distribution of medfly *Ceratitis capitata* (Diptera: Tephritidae) adults captured in the traps was analyzed in citrus orchards where mass trapping was applied to control the pest, with the objective of understanding how the method works, to determine the factors which influence it and to suggest changes which could improve its efficacy. A network of traps for mass trapping was established in 31 citrus orchards in Ibiza Island, from 2006 to 2008. The traps were of the tephri-trap type and baited with Tripack as attractant; they were uniformly distributed at a density of 50 per hectare following the standard recommendations. All traps of the mass trapping arrangement were sampled at intervals of 30 to 45 days by counting all flies captured on each trap. In all, 110 samplings, with a mean of 102 traps per sampling, were observed. Our results show that the establishment of the network of traps causes a barrier effect, with a gradual and rather constant reduction in medfly captures from the periphery to the interior of the area covered. The reduction rate observed is usually low: the average captures were 3.5 flies per trap and day (ftd) on the external edge row of traps and 2.3 ftd on the second row of traps, reaching 0.7 ftd on the sixth row located 70 meters inside the orchard. The following factors were analyzed for the barrier effect on medfly populations: size and shape of the orchard, presence of mature fruits, species and/or variety of fruit, month of the year, time elapsed since the mass trapping was laid out, and overall medfly abundance in the periphery of the area protected. The factors that showed significant influence were the size and shape of the orchard, and the month of the year: larger plots and plots with minimum ratio perimeter/area showed higher capacity in reduction of captures from the exterior to the interior of the plot, and the efficiency of the system of control increases in June and July. According to these results, the success of mass trapping can be measured by the capacity to get high levels of reduction between the external and the internal traps in the plot. The mass trapping technique must be applied in large areas, of several tens of hectares, in surfaces with a compact shape in order to minimize the perimeter, and increasing the density of traps in the periphery of the protected area. Traps should be installed...
when fruit ripening approaches but not before as no improvement was observed when traps were established in earlier periods of fruit development.

Section II: Other citrus pests

Diffusion of secondary insect pest species of citrus in Italy
P. Suma, F. Conti, G. Cocuzzza, E. Raciti, L. Zappalà, R. Fisicaro,
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Patterns of change in population abundance of citrus pest species obtained from an area-wide field survey and monitoring network established in eastern Spain
Ferran Garcia-Marí ................................................................. 55-60

Abstract: The establishment of scientifically sound warning, forecasting and early diagnosis systems is one of the priorities established by EU directives for pest management. These field monitoring programs generate also information useful to define patterns of change in pest abundance and to identify possible influencing factors. We present pest population patterns obtained from data of an area-wide survey and monitoring network established by the autonomic Government of the Comunitat Valenciana in the 180,000 ha citrus belt in eastern Spain between 2004 and 2009. The network was established for quarantine purposes and to assist farmers in pest management decisions. Four hundred orchards were monitored biweekly all along the year, determining population levels of 22 pest species. Weather data from 30 climatic stations in the area were also collected. Our results show that species of citrus have a strong influence on abundance of some species (diapridid scales) but not on others (coccid scales). Some pests show intense fluctuations in abundance from year to year (Tetranychus urticae, Paraleyrodes minei, Ceroplastes floridensis, Closterotomus trivialis), whereas others remain stable (Phyllocnistis citrella, Planococcus citri, Aphis spiraecola, Aonidiella aurantii). Some pests are linked to the same geographic area year after year (Paraleyrodes minei, Icerya purchasi, Ceroplastes sinensis), whereas others change geographic preference from year to year (Panonychus citri, Planococcus citri, Aleurothrixus floccosus, Phyllocnistis citrella). Finally, population trends in abundance along the year remain stable year after year in some cases (Aphis spiraecola, Aleurothrixus floccosus, Icerya purchasi) but not in others (Tetranychus urticae, Paraleyrodes minei, Saissetia oleae). Differences in abundance and trend patterns observed are likely related with differences in interacting factors which regulate and/or condition pest populations, either ecological (climate, biological control, plant physiology, food availability) or biological (dispersal, voltinism, growth rate).

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Thysanoptera species infesting the flowers of citrus in the eastern Mediterranean region of Turkey
Murat Ölçülü, Ekrem Atakan ................................................................. 63-69

Abstract: Production of citrus, an important crop for both domestic consumptions and exports, has been increasing year by year in Turkey. Nearly 65% of total citrus production is provided by Adana, Mersin and Hatay provinces located at the eastern Mediterranean Region of Turkey. Considerable numbers of pest species (89 species) cause damage to citrus plants in Turkey and 16 of them are often reported as important species. Some Thysanoptera (thrips) species are considered as pests on citrus in some ecological region of the world. Thrips species occurring in citrus flowers were studied in the eastern Mediterranean region of Turkey in 2009-2010. Twelve species belonging to three families were identified. In all samples collected, the most abundant species in total adult populations were western flower thrips, Frankliniella occidentalis (Pergande) (37.6% in 2009 and 40.6% in 2010), onion thrips, Thrips tabaci Lind. (24.9% in 2009 and 23.5% in 2010), Kelly’s citrus thrips (KCT), Pezothrips kellyanus (18.8% in 2009 and 16.6% in 2010) and Thrips major Uzel (13.9% in 2009 and 11.5 in 2010). P. kellyanus was detected only in Hatay province and collected mostly from lemon flowers, consisting of 46.2% and 48.3% of total adult population in 2009 and 2010, respectively. The fruit damage of scarring due to thrips (probably KCT) was higher on lemon fruits in that province than those found in other sampling areas, reaching 6.9% in 2009 and 4.1% in 2010.

Factors explaining variation in citrus fruit scarring by Pezothrips kellyanus (Thysanoptera: Thripidae)
Cristina Navarro-Campos, Apostolos Pekas, Amparo Aguilar, Ferran Garcia-Marí ................................................................. 71-76

Abstract: Pezothrips kellyanus, Kelly’s citrus thrips, is a recently recorded citrus pest in southern Australia, New Zealand, Hawaii, Chile and several countries of the Mediterranean Basin. In eastern Spain citrus orchards, P. kellyanus causes important economic losses due to fruit scarring since 2008. Nevertheless, damage by P. kellyanus is highly variable from one geographical area to another and from year to year. The goals of the present study were: (1) to study the changes in abundance of thrips species since the invasion of P. kellyanus in Spain, (2) to elaborate an adequate sampling plan, and (3) to identify possible factors influencing fruit scarring by P. kellyanus. We identified thrips species captured in white sticky traps in 8-19 orchards from 2005 to 2008. Regarding the sampling plan, thrips populations were periodically recorded by sampling citrus flowers and fruitlets in 4-14 citrus orchards from 2008 to 2010. Injury at each grove was obtained directly from the average percentage of fruits with fruit scarring. Finally, we used data of P. kellyanus abundance and fruits damaged by P. kellyanus in 200-1800 orchards from the monitoring networks established by the autonomous Government of the Comunitat Valenciana and by Bayer CropScience between 2005 and 2012. Only four years after its first detection in Spanish citrus, Pezothrips kellyanus represented 85% of thrips species captured in citrus trees, while Frankliniella occidentalis accounted only for 7% of the species captured, suggesting that P. kellyanus has displaced quite rapidly other thrips species in the citrus canopy. We have obtained an Economic Injury Level of 7% of fruitlets occupied by larvae of P. kellyanus. Citrus fruit scarring caused by P. kellyanus varied considerably from year to year and from one geographical area to another. The above variation is likely to be associated with air temperature, the citrus species, and the presence of late maturing varieties in the area. The implications of these factors, together with the soil management and the presence of natural enemies of P. kellyanus, are discussed.

Thrips species composition and seasonal dynamic populations in an organic citrus orchard in the central eastern coast of Tunisia
Mohamed Elimem, Brahim Chermiti ................................................................. 77-82

Abstract: In Tunisia, citrus hold an important place in the agricultural sector, and is considered a strategic product to which the state attaches great importance. Thrips species composition in an organic citrus orchard in the region of Chott-Mériem, in the central eastern coast of Tunisia, was
Impact of three ant species on pest populations in Mediterranean citrus orchards

Altea Calabuig, Apostolos Pekas, Ferran García-Mari .................................................. 83-87

Abstract: We conducted an ant-exclusion experiment to study the influence of three ant species, the native to the Mediterranean Pheidole pallidula (Nylander) and Lasius grandis (Forel) and the invasive Linepithema humile (Mayr), on the population densities and parasitism rates of three citrus pests: the honeydew producer woolly whitefly Aleurothrixus floccosus (Maskell) and the non-honeydew producers, California red scale Aonidiella aurantii (Maskell) and citrus leafminer Phyllocnistis citrella (Stainton). The ant-exclusion was carried out in three citrus orchards, each one dominated by one ant species, from April 2011 to November 2012. We measured ant activity, California red scale densities on fruits and twigs, whitefly and citrus leafminer population densities as well as the parasitism of these pests in ant-allowed and ant-excluded trees. The most active ant species was L. humile, while P. pallidula and L. grandis showed considerably lower activity levels. On fruits, A. aurantii densities in the ant-excluded trees were on average 27% lower for the three ant species studied than in the ant-allowed trees. On twigs, differences in A. aurantii densities were detected between treatments only for L. grandis. In the case of A. floccosus, differences between ant-excluded and ant-allowed treatments were found for P. pallidula and L. humile. For P. citrella, we found no significant differences in the percent of leaf surface loss. Regarding the parasitism, we only found higher percent parasitism in the case of P. citrella in L. humile dominated orchard. These results show that ant activity may have an effect on the abundance of honeydew and non-honeydew producing pests, yet this effect depends on the ant species involved. This effect is possibly not produced through parasitism since our results show no differences in percent parasitism for the three ant species studied between ant-allowed and ant-excluded treatments.

Sampling methods for estimating ants’ abundance on citrus trees

Maria Teresa Martínez-Ferrer, José Miguel Campos Rivela ........................................... 89-93

Abstract: Ants are considered a secondary pest in citrus. The damage they cause is indirect, through the biological control disruption of pests, especially honeydew producers. Furthermore, ants play other important ecological role such as predation of other arthropods, seed dispersal and soil structure maintenance. In IPM Programs, adequate and precise sampling methods would enable growers to more accurately determine when to perform chemical ant control, therefore saving costs on unnecessary chemical treatments and reducing risk of crop loss by pests. Ants access the citrus tree canopies mainly through the trunk for searching honeydew producers. In 26 citrus commercial groves located in Northeast Spain, the ant species composition and abundance in trunk were assessed in 100 samplings during 2011 and 2012. Eight ant species were found, differing in abundance and frequency: Lasius grandis, Pheidole pallidula, Plagiolepis pygmaea, Formica gerardi, F. rufibarbis, Camponotus sylvaticus, Linepithema humile and Tapinoma erraticum. Aggregation indices on the trunk of these species were calculated using Taylor’s

studied during the years 2010 and 2011. Twelve thrips species were identified and monitored. The most abundant species were Frankliniella occidentalis Pergande (32.97% in 2010 and 27.93% in 2011), Melanthrips fuscus Sulz. (18.56% in 2010 and 21.71% in 2011), Thrips tabaci Lindemann (11.14% in 2010 and 11.84% in 2011) and Pseudothrips kelleyanus Bagnall (8.2% in 2010 and 10.4% in 2011). Dynamic populations of those eudominant species was also studied showing that they occurred especially during spring and hot summer except for M. fuscus whose population developed the most during the cold season. On the other hand, three predatory thrips species were identified and monitored, Aeolothrips tenuicornis Bagnall, the eudominant thrips predator species (18.46% in 2010 and 18.64% in 2011), A. fasciatus L. and Frankliniorthrips megalops Trybom that were both subdominant species in 2010 (3.21% and 3.62%, respectively) and subrecedents in 2011 (2.03% and 1.97%, respectively). It must be noted that two thrips species were absent during 2010 and occurred only in 2011: Microcephalothrips abdominalis Crawford, whose presence was recedent with a percentage of about 1.43%, and Ceratothrips frici Uzel (1895), a subrecedent species with only 0.3% of total thrips population in the citrus orchards.
power law. Enumerative and binomial sampling plans for the most abundant and frequent species in citrus, *L. grandis* and *Ph. pallidula*, were developed.

**The impact of honeydew-seeking ants on Coccus hesperidum biological control in citrus groves**
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**Diet of grasshoppers belonging to the family Pamphagidae (Orthoptera)**
*Naima Benkenana, Abboud Harrat, Daniel Petit* ......................................................... 96
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**Section III: Beneficial arthropods and biological control**

**Conservation and classical biological control of Satsuma citrus pests in western Turkey**
Abstract: Western part of Turkey is the second largest producer of Satsuma mandarin in Turkey for fresh consumption and export to Europe. Satsuma citrus is the host for many pests, mainly sucking insects belonging to order Hemiptera. Satsuma citrus mites, whiteflies, scale insects, and the citrus leafminer, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) are controlled by either native and/or introduced natural enemies, successfully established by several classical biological control studies over the last few decades. Conservation of natural enemies with high summer temperatures makes it unnecessary the need for insecticidal application for aphid pests. Only the Mediterranean fruit fly *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) cannot be suppressed without chemical control. There is no need to use any control measures for the European leaf roller *Archips rosana* L. (Lepidoptera: Tortricidae) and leafhoppers. The status of biological control, including classical and conservation strategies, against Satsuma citrus pests in western Turkey is reviewed. Overall, conservation of natural enemies seems to be an essential component of the management of pests in Satsuma citrus in Western Turkey, thus the most important step for using biological control lies in producers’ willingness to accept it and in training for increasing sensitivity to human and environment health.

**Spatiotemporal structure and diversity of the fauna of beneficial insects in citrus orchards of central Mitidja (Algeria): Population dynamics along the season**
*Leïla Benfekih, Ferran Garcia-Mari, Houda Mostefaoui, Altea Calabuig, Cristina Navarro-Campos, Abdelhaq Mahmoudi, Bilal Aoudia* ................................................. 109
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**Influence of ecological infrastructures on the increase of biodiversity and conservation of beneficial arthropods in citrus orchards**
*R. Laborda, S. Bertomeu, A. Sánchez, P. Xamani, S. Tarazona, J. M. Ibáñez, A. García, F. García-Mari* ........................................................................................................ 111-115
Abstract: We performed a study in nineteen citrus plots representative of the agricultural landscape of the municipality of Altea (100 km south of Valencia, in eastern Spain) in order to determine the influence of ecological infrastructures on biodiversity and conservation of beneficial arthropods. The landscape was dominated by small citrus orchards mixed with low density urban areas, a consequence of touristic urban pressure. We have considered five factors: pest management system (zero residues vs. conventional), size of the plot, distance to nearest natural habitat, presence/absence of cover crop, and presence/absence of other non-citrus fruits in the plot. Four of the five factors showed a positive influence on biodiversification and
conservation of beneficials: small plot size, short distance to natural habitat, presence of vegetation cover and presence of other fruits. These are the factors to promote in order to develop biological strategies alternative to traditional pesticide use in the management of citrus pests. Only the factor “pest management system” does not show a significant influence on biodiversity or on abundance of biological control agents.

Evaluation of ecological infrastructures in the conservation and management of natural enemies as an alternative to pesticide use in the agricultural landscape of the Altea municipality (eastern Spain)
R. Laborda, S. Bertomeu, P. Xamani, A. Sánchez, S. Tarazona, J. M. Ibáñez, A. García, F. García-Mari ................................................................. 117-120

Abstract: We determined the functional biodiversity in a significant area of the agricultural landscape of the municipality of Altea (100 km south of Valencia, eastern Spain). The quality of the ecological infrastructures was analyzed following the methodology proposed by the IOBC (Ecological Infrastructures. Idea Book on Functional Biodiversity at the Farm Level). The local landscape is a network of small agricultural plots, predominantly citrus, sprinkled with low-density urban areas due to tourist pressure suffered by the Spanish Mediterranean coast in recent decades. Four parameters are evaluated in the group of selected plots: sustainability of the crop, biodiversity of trees and cover crops, the crop connectivity, and the structural diversity of the crop. The results show that the agrarian typology studied forms a diversified area, well connected to the landscape and to the ecological infrastructures present. It is concluded that the study area has a median level of biodiversity. Even so, the low diversification of crops, their compromised sustainability, and the lack of a diversified arboreal structure alternative to the crop, fail to provide an optimal habitat for the beneficial fauna. Correcting these aspects could improve the diversity of pest natural enemies, thus allowing to progress in a strategy of eliminating the use of pesticides in the area.

Life table parameters of Chilocorus bipustulatus (L.) (Coleoptera: Coccinellidae) on two different prey [Aspidiotus nerii (Bouche), Hemiptera: Diaspididae] densities
Sedat Sevinç, Ismail Karaca, M. Salih Özgökçe ................................................................. 121-129

Abstract: In this research, the life table of Chilocorus bipustulatus was investigated on two different prey densities. Aspidiotus nerii was used as prey and two groups of the predator were fed daily 320 and 640 prey, beginning from the first instar till the death of the last individual. Durations of larval and pupal stages and egg numbers of adults per day were determined. Trials were performed in a climatic chamber with 26 ± 1 °C temperature and 65 ± 1% RH. As a result of the experiments, net reproductive rates of C. bipustulatus individuals fed with 320 and 640 prey were 13.827 and 35.554 females/female, while intrinsic rates of increase were 0.066 and 0.100 females/female/day, and mean generation times were 40.022 and 35.669 days, respectively. Best survival rates of each experimental group were calculated according to Weibull distribution and best survival fits were found for both groups. Parameters of best survival rates were determined as b = 3.97, c = 0.62 for the group fed on 320 prey and b = 8.13, c = 0.94 for the group fed on 640 prey. According to these results both groups have Holling’s type III survivorship curves. Fecundity of C. bipustulatus was determined with Enkegaard equation. Best-fit parameters of fecundity were calculated as a = 1.34, b = 0.16; and a = 1.95, b = 0.21 for 320 and 640 prey groups, respectively.

Parasitoids and hyperparasites of citrus aphids in northern east of Tunisia (Cap Bon)
Essia Limem Sellami, Gerard Delvare, Brahim Chemriti .................................................. 131-139

Abstract: A field survey of parasitoids of citrus aphids was undertaken in the Cap Bon region (northern east of Tunisia) during the years 2010 and 2011. Four citrus orchards (2 organic farming orchards, 2 conventional farming orchards) were sampled every 15 days during the two years. Aphid mummies were collected from young shoots. Citrus were attacked by five species of
aphids, *Aphis gossypii* (Glover) *Aphis spireacola* (Pagenstecher), *Toxoptera aurantii* (Boyer), *Myzus persicae* (Sulzer) and *Macrosiphum euphorbiae* (Thomas). Five species of primary parasitoids were collected, *Lysiphlebus testaceipes* (Cresson), *Lysiphlebus fabarum* (Marshall), *Binoxyx angelicae* (Haliday), *Aphidius matricariae* (Haliday) and *Aphidius colemani* (Viereck). Six species of hyperparasites were also identified, *Pachyneuron aphidis* (Bouché), *Pachyneuron muscarum* (L.), *Asaphes vulgaris* (Walker), *Asaphes suspensus* (Nees), *Phaenoglyphis villosa* (Hartig) and *Alloxysta victrix* (Westwood). All the hyperparasites were identified to species for the first time in Tunisia. *Lysiphlebus testaceipes* was, by far, the dominant species of primary parasitoids in term of frequency in all the studied sites, while *Pachyneuron aphidis* was the dominant species of hyperparasite. The survey of parasitism rate in the first organic farming (site A) shows that it reached 14 and 17% in 2010 and 2011 in the period of May-June. The diversity Shannon index (H’) in the different study sites ranged from 1.5 to 1.88 depending on the locality.

**Abstract:**

Selda Telli, Abdurrahman Yiğit

Six species of hyperparasites were also identified, *Pachyneuron aphidis* (Bouché), *Pachyneuron muscarum* (L.), *Asaphes vulgaris* (Walker), *Asaphes suspensus* (Nees), *Phaenoglyphis villosa* (Hartig) and *Alloxysta victrix* (Westwood). All the hyperparasites were identified to species for the first time in Tunisia. *Lysiphlebus testaceipes* was, by far, the dominant species of primary parasitoids in term of frequency in all the studied sites, while *Pachyneuron aphidis* was the dominant species of hyperparasite. The survey of parasitism rate in the first organic farming (site A) shows that it reached 14 and 17% in 2010 and 2011 in the period of May-June. The diversity Shannon index (H’) in the different study sites ranged from 1.5 to 1.88 depending on the locality.

**Aphids and their predators and parasitoids in citrus of eastern Mediterranean region of Turkey**

**Serdar Satar, Gül Satar, Mehmet Karacaoğlu, Nedim Uygun, Petr Stary**

**Abstract**

**Efficiency of Cryptolaemus montrouzieri Mulsant (Coleoptera: Coccinellidae) to control Planococcus citri Risso (Hemiptera: Pseudococcidae)**

in citrus orchards in Tunisia

**Ridha Rahmouni, Braham Chermiti**

**Abstract:** The study of the efficiency of the predatory ladybird *Cryptolaemus montrouzieri* against *Planococcus citri* was conducted in two Citrus orchards variety “Maltaise” in the region of Mornag and “Maltaise douce” in the region of El Gobba in northern Tunisia. This study revealed that *C. montrouzieri*, which was introduced and multiplied in Tunisia since 2006, is capable of controlling the populations of *P. citri* and maintain them at an economically tolerable threshold one month after their releases. Indeed, the density of eggs of *P. citri* decreased by 85% compared to the initial populations in El Gobba and 89% in Mornag orchard. After a period of approximately three months of the first releases of adults of *C. montrouzieri*, the population structure of *P. citri* was composed of 7.67% of eggs, 0% L1, 7.56% of L2, 4.86% of L3 and 10% of females in the orchard of El Gobba. By contrast, in Mornag, the population of *P. citri* was maintained at a relatively higher level with 11.27% of eggs, 14.56% of L1, 24% of L2, 18.42% of L3 and 13% of females. Thus, we can conclude that *C. montrouzieri* can be considered as an effective biocontrol agent against *P. citri* in Tunisia.

**Functional response of Leptomastix dactylopii How. (Hymenoptera, Encyrtidae) on citrus mealybug, Planococcus citri Risso (Hemiptera, Pseudococcidae)**

**Selda Telli, Abdurrahman Yiğit**

**Abstract:** The exotic parasitoid *Leptomastix dactylopii* How. is used in biological control of citrus mealybug, *Planococcus citri*, one of the main insect pests which causes quality and quantity loss in citrus plantations. The number of parasitized *P. citri* individuals, parasitization ratio and sex ratio of emerged *L. dactylopii* adults according to varying host densities were determined at 25 ± 2 °C, 70 ± 10% R.H. and 16 h/day photoperiod conditions. Mated one-day old *L. dactylopii* females were confined with a sprouted potato infested by *P. citri* nymphs (N3) and virgin females, with densities of 10, 20, 40, 80 and 100 individuals, and allowed to forage for 72 hours within plastic jars of 10 cm diameter and 9 cm height. Afterwards, *L. dactylopii* females were removed from jars and *P. citri* nymphs (N3) and virgin females were checked for mummified individuals, the measure of a successful attack. Parasitoid adults were recorded for 30 days, beginning with the first emergences, which started on the 17th day. As a result of this study, higher attack numbers occurred as the number of mealybugs increased. The parasitization ratio of *L. dactylopii* was 100% at the lowest host density. The ratio decreased gradually as the
host density increased (97.0, 92.0, 84.50 and 70.0%, respectively). The sex ratio was in favour of the parasitoid females for each of the host densities. The type of the parasitoid response to the increasing host densities best fitted to Holling’s type II model, which is considered to be an efficient parasitoid species in biological control of agricultural pests.

Effect of different food on adult productivity of *Sympherobius pygmaeus* (Rambur) (Neuroptera: Hemerobiidae)

*Miraç Yayla, Serdar Satar* ................................................................. 153-160

**Abstract:** As in many other beneficial insects, biological studies are carried out on Chrysopidae and Hemerobiidae (Neuroptera) in order to increase the density of their populations in nature. Within a developed variety of methods, two of them are the most popular. One is mass production and release of beneficial insects to nature and the other is applying artificial foods on crop plants to ensure that adults lay more eggs. In this study, adult *Sympherobius pygmaeus* lifetime and egg numbers were compared according to results obtained by feeding on different foods. Four different artificial and natural food experiments were carried out at 25 °C constant temperature with 60 ± 10% relative humidity in (16:8) long day lighting climate cabinets. In this experiment, water, 10% of honey-water, mealybug and mealybugs + 10% honey-water were given as nutrients to determine adult *S. pygmaeus* total egg, daily egg production, and the periods of preoviposition, oviposition, postoviposition and total lifetime. When foods given to adult *S. pygmaeus* were compared, the highest daily egg rate (30.34 eggs/female/day) was observed with the mealybug and the lowest (1.74 eggs/female/day) with water. The maximum preoviposition period (4.00 days) was obtained with water and the lowest (1.40 days) with mealybug + 10% honey-water. When the effects of different foods to the lifetime were examined, the longest lifetime was 22.70 days for mealybug while the shortest was 9.38 days for water. The highest total number of eggs and daily egg number were 349.67 and 30.34, respectively, on mealybug as food; the lowest was 15.87 and 1.74, respectively, on water. Finally, the highest intrinsic rate of increase (*r_m*, females/female/day) was 0.128 in the mealybug nutrient experiment and the lowest was found to be 0.054 for water. The net reproductive rate (*R_o*, females / female) parameter obtained was 150.7 for mealybug and the lowest 6.8 for water.

Parasitoids and predators of citrus leafminer, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) in east Mediterranean region of Turkey

*Naiime Z. Elekçioglu* ............................................................................. 161-168

**Abstract:** The citrus leafminer (CLM), *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) is considered as an important pest of citrus, damaging mainly nursery plants. In Turkey, it was first recorded in 1994 and rapidly spread to all citrus growing areas of the country. Due to its wide expansion and damage, efforts were initiated to control this pest with biological control agents and species composition was investigated. This study illustrates our continuous studies on the parasitoids and predators of the pest in east Mediterranean region of Turkey. Eleven species of parasitoids were identified: *Cirrospilus brevis* Zhu, LaSalle & Huang, *C. pictus* (Nees), *C. variegatus* (Masi), *C. vittatus* Walker, *C. ingenuus* Gahan, *Citrostichus phylostictoides* (Narayanan), *Semielacher petiolata* (Girault), *Pnigalio incompletus* (Bouček), *P. mediterraneus* Fer.-Del., *Diglyphus isaea* (Walker), *Neochrysocharis formosa* (Westwood) (Hymenoptera: Eulophidae) and unidentified individuals belonging to 7 genera [(*Neochrysocharis* sp., *Chrysocharis* sp., *Chrysonotomyia* sp., *Baryscapus* sp., *Pnigalio* sp., *Sympees* sp. (Hymenoptera: Eulophidae) and *Pteromalus* sp. (Hymenoptera: Pteromalidae)]. *Chrysoperla carnea* Steph. (Neuroptera: Chrysopidae), *Oenopia* (*Synharmonia*) conglobata (L.), *Scymnus rubromaculatus* (Goeze), *Scymnus* spp., (Coleoptera: Coccinellidae), *Orius* spp. (Hemiptera: Anthocoridae), ants and spiders were determined as predators of the pest.
Parasitic complex of citrus leafminer *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) in Algeria
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Enhancing the oviposition and population development of the predatory mite *Euseius stipulatus* in citrus
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Acarina fauna of citrus trees in eastern Mediterranean region of Turkey
*Serdar Satar, Murat Ada, İsmail Kasap, Sultan Çobanoğlu* ............................ 171-178
Abstract: Acarina includes important pest and predator species in citrus orchards. As pests this group caused important economic losses in recent years. So, Acarina species in citrus orchards were surveyed in Adana, Mersin, Osmaniye and Hatay provinces in eastern Mediterranean Region of Turkey in 2008 and 2009. Citrus leaves, buds, flowers and fruits were individually examined using a 10× hand magnifier and mites were taken by fine brush and preserved in tubes containing 70% ethanol. Collected materials were transferred to specialist for identification. The most common species determined were *Amblyseius andersoni* Chant, *Typhlodromus athiasae* Porath and Swirski, *Euseius stipulatus* (Athias-Henriot), *Euseius scutalis* (Athias-Henriot), *Paraseiulus talbi* (Athias-Henriot), *Paraseiulus triporus* Chant & Yoshida-Shaul, *Euseius finlandicus* Oudemans, *Kampimodromus aberrans* (Oudemans), *Zetzeilla mali* Ewing as predators; *Tydeus californicus* Banks as neutral; *Panonychus citri* McGregor, *Panonychus ulmi* Koch, *Tetranychus urticae* Koch, *Brevipalpus lewisi* McGregor, *Phyllocoptora oleivora* (Ashmead) and *Aceria sheldoni* (Ewing) as pests. *Panonychus citri* and *Phyllocoptruta oleivora* were considered as the most common pests, *Amblyseius andersoni* and *Typhlodromus athiasae* as the most common predators. *Citrus sinensis* and *C. limon* have more number of acarina species compared to *C. reticulata* and *C. paradisi*.

Biocontrol of *Tylenchulus semipenetrans* and phytopathogenic fungi of citrus by rhizobacteria from Tunisian citrus rhizosphere
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Section IV: Pesticide effects and IPM

Effects of different insecticides on life stages of *Planococcus citri* Risso (Hemiptera: Pseudococcidae)
*Gül Satar, Haci Fatih Ateş, Serdar Satar* ..................................................... 183-190
Abstract: This study was conducted to detect the effect of some insecticides against different life stages (egg and nymph) of *Planococcus citri* Risso (Hemiptera: Pseudococcidae), a harmful pest on citrus plantations in recent years. Five different active substances (summer oil, Imidacloprid, Chlorpyrifos-ethyl, Buprofezin, Spirotetramat) were used in the study. Abbot and Henderson Tilton analyses were used to evaluate results. All used insecticides had negative effect on hatching of eggs. Buprofezin (68.4%) and Spirotetramat (71.2%) have lesser effect on it than the others. Although summer oil showed its effect shorter time than Imidacloprid and Chlorpyrifos-ethyl, the three insecticides caused 100% mortality on eggs. The number of eggs in eggs masses decreased with Buprofezin (93.0) and Spirotetramat (77.6) compared with the control (110.8). Nymph stage experiments were carried out for seven days. At the end of this period all insecticides caused 100% mortality. All nymphs died within three days for Buprofezin and Chlorpyrifos-ethyl and seven days for summer oil, Imidacloprid and Spirotetramat. When comparing the insecticides, summer oil and chlorpyrifos ethyl look a better control option than
the others for citrus mealybug. However, their effects on biological control agents and non-target organism should be determined for a better decision.

Evaluation of insecticide effect of the essential oil extracted from the *Citrus aurantium* leaves on the black orange scale *Parlatoria ziziphi* Lucas, 1893 (Hemiptera, Diaspididae)
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Comparative study of the effectiveness of the essential oils formulated of thyme and origan on different aphids
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Evaluation of the toxicity of organic products on *Toxoptera aurantii* (Homoptera: Aphididae) in citrus of the central Mitidja (Algeria)
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Effect of white oil on the parasitoid of citrus mealybug
*Leptomastix dactylopii* Howard (Hymenoptera: Encyrtidae)
*Zühal Erenler, Neşet Kılınçer, Hilal Tunca* ..................................................... 195-201
Abstract: Citrus is one of the most important export products and citrus production is one of the most developing agricultural sectors in Turkey. Citrus mealybug is one of the main pests of citrus. Biological control is often preferred against citrus mealybug because mealybug control with chemicals is quite difficult due to the wax that covers the insect and its habit of feeding in dark and inner places. The parasitoid *Leptomastix dactylopii* Howard (Hymenoptera: Encyrtidae) can suppress the mealybug population. As it is thought that the activity of natural enemies is intensive in citrus orchards, it is important to know the impact of white oils on natural enemies. For this reason, the effects of the white oils used widely in citrus orchards on some biological aspects of parasitoid *L. dactylopii* were determined in laboratory condition. The experiments were conducted on 28 ± 1 °C temperature, 65 ± 10% relative humidity and 16:8 h light: dark photoperiod conditions. The effects of the white oil applied at 0, 2, 4, 6 and 8 days after parasitization of citrus mealybug on different ages were examined. The period of maturity of the parasitoid grown in young female mealybugs increased compared to control, while the time to full grown in third instar mealybugs decreased. Ratio of being mummy and emergence increased with the application time in both host ages. Longevity of female and male parasitoids emerged from third instar mealybugs increased with the exposure time. No differences were observed in male parasitoid when longevity of female parasitoid emerged from young female mealybugs decreased. These results could help to further improve the safe use of white oil in IPM.

Preliminary antimicrobial characterization of essential oils extracted from the citrus Tunisian variety "Malaise demi-sanguine"
infected with viroïds
*Nadia Chammem, Asma Najar, Ines Sifaoui, Chokri Jéribi, Manef Abderabba, Moktar Hamdi* ................................................................. 203
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Occurrence of Alternaria brown spot on citrus in Tunisia
Maali Haddad, Naima Boughalleb-Mhamdi, Antonio Vicent, Mohamed Cherif ......................................................... 213-221
Abstract: Alternaria brown spot is a serious disease of fruit and foliage of citrus and is responsible of serious losses on susceptible cultivars in the north of Tunisia. A severe outbreak of brown spot was observed on tangerine (Citrus reticulata Blanco) and hybrids of tangerine for the first time in 2008. Symptoms at the initial stage of the infection showed brown, small, scattered spots on the leaves that gradually become round or irregular. Spots coalesce to affect large areas of the leaves and cause defoliation. The disease first appeared in April and remained till June when temperature ranged from 15 to 27 °C. Fungus isolates obtained from infected leaf tissues, grown in pure culture, were identified as Alternaria alternata (Fr.) Keissler on the base of morphological characteristics of colony and conidia and confirmed by sequencing. The fungus produced olivaceous black colonies with dark olive green margins, and abundant branched septate, golden brown mycelium. The conidiophores were branched, straight, pale brown to olive brown. The conidia of the isolates were catenated in long, sometimes branched chains of 4-8 spores. Leaves and fruits of 18 citrus cultivars were inoculated with conidia of three isolates of Alternaria alternata. Pathogenicity tests indicated that mandarins were susceptible to tested isolates. All lemon cultivars as well as the Star Ruby were not susceptible. As far as oranges are concerned, Valencia Late and Navel Late were not susceptible, while Lane Late and Maltaise were slightly susceptible.

Present status of citrus blast disease in Cukurova region in Turkey
Raziye Cetinkaya Yildiz, Sumer Horuz, Mustafa Mirik, Yesim Aysan .................. 223-226
Abstract: Citrus blast disease, caused by Pseudomonas syringae pv. syringae, in 1991, had a severe outbreak in Erdemli, a province of Mersin, in the eastern of Mediterranean region of Turkey and so far, the blast disease got a great importance in this region. Characteristic disease symptoms were first seen on leaves as water-soaked lesions and black areas on the petiole wings. Later, lesions extended to the mid-vein of leaves and to the twigs surrounding the base of the petiole. Finally, the leaves dried and rolled, while still firmly attached, before eventually dropping without petioles. The necrotic areas on twigs further enlarged and the twigs were eventually killed within 20-30 days. We investigated the disease susceptibility of the most
cultivated citrus plants in the region. Of the citrus varieties, *Citrus limon* cvs. Lamas, Enterdonate and Kutdiken were tolerant; *C. paradisi* cvs. Mars Seedless and Red Blush were less susceptible; *C. sinensis* cvs. Yafa, Valencia and Washington Navel, *C. reticulata* cvs. Clementine, Fremont, Satsuma and Mineola Tangelo, *C. paradisi* cv. Star Ruby were found the most susceptible varieties in citrus plants. In 2004, the disease appeared again and caused economically significant losses in *C. sinensis* cv. Washington Navel and Marisol. Many strains isolated from damaged petioles, wings and leaves of citrus trees. Eight years later, the new outbreak, in 2012, the disease symptoms has observed in *C. reticulata* cvs. Nova and Okitsu, *C. sinensis* cv. Washington Navel and *C. paradisi* cv. Star Ruby. Since 1991, according to observations, it is supposed that environmental conditions and citrus varieties have a great role on disease development in the region. Pathogen can cause severe outbreaks on susceptible citrus plants just after warm and raining spring time. Additionally, in last years, many stone fruit plantations were established in the region, and, also well known that the pathogen can damage those plants. Our further studies will be focused on newly introduced citrus varieties and those stone fruit plantations.

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