ENTOMOLOGIA HELLENICA

Τόμ. 32, Αρ. 3 (2023)

Special Issue: 19th Panhellenic Entomological Conference Proceedings, 23-27 May 2022, Agrinio, Greece

Understorey biodiversity management in olive groves for integrated management of natural enemies

Georgios Stavrianakis, Sophie Rosa Stattegger, Efstratios Sentas, Aikaterini Tsamakda, Ioannis Grumic, Thomas Tscheulin, Athanasios Kizos

doi: 10.12681/eh.35034

Βιβλιογραφική αναφορά:

Stavrianakis, G., Stattegger, S. R., Sentas, E., Tsamakda, A., Grumic, I., Tscheulin, T., & Kizos, A. (2023). Understorey biodiversity management in olive groves for integrated management of natural enemies. *ENTOMOLOGIA HELLENICA*, *32*(3), 17–24. https://doi.org/10.12681/eh.35034

ENTOMOLOGIA HELLENICA **32** (2023): 17–24

Received 24 July 2023 Accepted 03 August 2023 Available online 01 September 2023

Understorey biodiversity management in olive groves for integrated management of olive tree natural enemies

STAVRIANAKIS G.[1*], STATTEGGER S.R.[2], SENTAS E.[1], TSAMAKDA K.[1], GRUMIC I.[1], TSCHEULIN T.[2] AND KIZOS A.[1]

[1]Laboratory of Rural Geography & Precision Farming Systems, Department of Geography, University of the Aegean, Mytilene, Greece

[2]Laboratory of Biogeography & Ecology, Department of Geography, University of the Aegean, Mytilene, Greece

ABSTRACT

The management of natural enemies of perennial tree crops and especially insects, is usually performed with pesticides, which can negatively impact the quality of products, natural resources, and biodiversity, as well as the health of producers and consumers. An emerging trend focuses alternatively on the use of less or no chemicals and the management of crop pests by natural means. This trend is being promoted by the European Union through the new Common Agricultural Policy. Olive cultivation is one of the most important permanent crops in the Mediterranean area. The most important pest in olive groves is the olive fruit fly [*Bactrocera oleae* (Rossi) (Diptera: Tephritidae)]. In this study, we investigate the relationship between the fly population and plant and insect diversity in the understorey of 15 fields on Lesvos Island during the years 2021 and 2022. The results suggest that maintaining the plant cover undisturbed, significantly improves the biodiversity of the olive groves and by extension the ecosystem services, such as pollination, pest control and soil health.

KEY WORDS: Consumer's attitudes, pesticide residues, factor analysis, logistic regression, European Green Deal, integrated crop management.

Introduction

The increasing world population has led to the intensification and extensification of the agricultural sector to achieve higher yields (Bennet & Balvanera 2007). One of the most common practices of intense farming is the use of insecticides and involves many risks, such as the development of insecticide resistance (Vasconcelos et al. 2022). Plantations and permanent crops have followed these trends with an increasing number of farms choosing small size varieties in order to increase density, industrialize procedures and, at the same time, treat them with increased use of inputs in order to ensure the, quantitively, increased production. One of the most important and widespread permanent crops in Europe and the Mediterranean region, culturally and socioeconomically, is olive tree cultivation (Martinez-Nunez et al. 2019). The European Union and the local governments have clearly advocated the reduction of the use of chemical substances that are released into the environment, and their replacement with more environmentally friendly agents and methods, principles that have been expressed in the Common Agricultural

**Corresponding author: gmstavrianakis@geo.aegean.gr*

Policy (CAP) (Pe'er et al. 2019), especially after the enforcement of "Green deal" and the strategy "Farm to Fork".

The intensification of the olive cultivation affects biodiversity and leads to impoverishment of agroecosystems (Bianchi et al. 2006; Biaggini et al. 2006). It has been established that the agrobiodiversity of the understorey of olive groves, among other factors, contributes to the reduction of plant protection issues in the agricultural production through the support of beneficial insects that are not affected by spraying, by providing habitats or refuges (Porcel et al. 2017; Hole et al. 2005 Fierer et al. 2007; Tilman et al. 2001).

Maintaining an undisturbed understorey benefits the development of larger soil arthropod populations (Blaise et al. 2022; Mantoni et al. 2021; Castro et al. 2021). Arthropods found in the soil of the olive grove understorey have been shown to be able to contribute to the integrated treatment of the olive fruit fly *Bactrocera oleae* (Rossi) (Daane and Johnson 2010). Nevertheless, among insects, bees are a very important group of pollinators. Intensive agriculture (Potts et al. 2010), habitat loss, fragmentation and degradation, affect the availability of key foraging and nesting resources (Tscheulin et al. 2011). According to Martinez-Nunez et al. (2019), bees can benefit from the presence of ground herb cover as they found that colonization rates were higher in olive orchards, in which the understorey was unmanaged.

For all these reasons, it is necessary to investigate how understorey management affects diversity and abundance of arthropods in olive groves. In this study, we monitor land cover, ground arthropod and flying insects and olive fruit fly in the understorey of extensive olive groves on the Island of Lesvos, Greece for two cultivation periods.

Materials and Methods

For the purposes of this study, we selected fifteen organic olive groves located on the island of Lesvos, Greece, which were treated with equal intensity. The olive groves were grouped into two categories according to the understorey management practices: (a) undisturbed understorey, and (b) understorey cleared with mechanical means.

The diversity of the plant ground cover of the olive groves was assessed during May 2021 and May 2022, with four linear transect walks of 25m length each. Ground arthropods were monitored with pitfall traps (5 per olive grove) from February to November 2021 and February to November 2022, while the flying insects were sampled with pan traps (5 triplets per olive grove) during the same period. Both trap types were active for 7 days. The pan trap triplets consisted of bowls painted with UV-bright yellow, white, and blue color. The specimens captured were initially identified at order level using a binocular microscope and various taxonomic keys (Barrientos 1988; Dindal 1990; Chinery 2005). All Coleoptera and Anthophila Clade (Hymenoptera) were identified to morphospecies level.

Results

The first results show that the type of management of the olive groves' understorey has a significant impact on all the indicators studied in the survey. Specifically, as shown in Table 1, higher values of plant abundance and species richness were found in olive groves with

undisturbed understorey. Moreover, regarding arthropods, it was found that they had the same trend in this type of sub-floor management. The olive fruit fly was negatively affected by the understorey management, as the population was statistically significantly lower in the fields with plant cover.

To further investigate the reasons for the differences between the two types of understorey management, we correlated the studied factors (Table 2). The results showed that all studied arthropod groups have a strong positive relationship with plant species richness. Regarding the relationship with plant species richness of the understorey, it was found that only bee species richness was not statistically significantly correlated, although, here as well, the trend was positive. On the other hand, olive fruit fly had strong negative relationships with all studied arthropod groups and plant richness and abundance (Fig. 1). These relationships were statistically significant.

Discussion

The results show that both arthropod community and plant diversity were increased in olive groves whose understorey is left undisturbed compared to the other type of management, while olive fruit fly has the opposite response.

In general, plant cover in undisturbed understorey was more abundant and this could happen as it was left to grow without obstacles, while the organic practices could also be a factor for the higher plant richness (Kakampoura & Panitsa 2022). Interestingly, the annual plants were more abundant in cleared understoreys, but studies confirm this response (Huqi et al. 2009; Simoes et al. 2014; Solomou & Sfougaris 2011).

As for the arthropod community, the findings can be explained by the fact that an undisturbed understorey provides shelter, nesting sites, and forage, and supports a wide range of ecological processes, such as pollination. Other studies confirm the same findings and suggest that arthropods include species that provide many different ecological services such as pollination, decomposition, insect pest control and this type of understorey can support their population by creating a small ecosystem inside the agroecosystem of the olive grove (Kubiak et al. 2022; Picchi et al. 2016; Knapp et al. 2013).

The arthropod community as mentioned above is more abundant in fields with undisturbed understorey. Among these arthropods are predators and parasitic insects of the olive fruit fly that can control the pest's population when it is adult. At the same time, during the period that the olive fruit fly is pupating in the soil, certain species of predatory coleopterans and ants feed on the fly as it cannot defend itself (Albertini et al. 2018; Albertini et al. 2017; Dinis et al. 2016). These could explain the differences of the olive fruit fly population observed between the two understorey treatments.

In conclusion, this study emphasizes on the significance of olive grove understorey management practices in preserving biodiversity. These practices promote plant diversity, arthropod abundance, and pest control. Olive farmers should prioritize conserving understorey vegetation to support the arthropod community, ecosystem services, and ensure olive production sustainability. Moreover, the maintenance of an undisturbed understorey is in line with the principles of the Common Agricultural Policy (CAP) as it is classified as an environmentally friendly practice.

TABLE 1. Two samples t-test between overall arthropod richness, abundance, and the olive grove's understorey treatment.

	Understorey management			
	undisturbed		cleared	
	Average	Std. Deviation	Average	Std. Deviation
Ground beetle richness	6.21	0.75	2.99	0.59
Ground beetle abundance	14.33	2.15	6.03	2.04
Total ground arthropod abundance	34.18	4.17	12.01	2.00
Bee richness	4.59	0.82	1.44	0.43
Bee abundance	9.83	2.29	2.28	0.70
Flying insect abundance	86.23	20.27	15.21	7.07
Olive fruit fly	6.30	0.69	24.21	3.13
Plant richness	5.4	1.13	2.01	0.83
Plant abundance	58.01	8.37	33.60	18.03
Coleoptera	17.35	21.51	5.75	6.71
Hemiptera	4.68	4.50	1.21	1.01
Hymenoptera	12.76	10.66	2.04	1.49
Orthoptera	2.39	1.33	0.41	0.53
Diptera	8.48	5.42	2.81	1.49
Lepidoptera	1.11	1.35	0.06	0.12
Odonata	0.35	0.42	0.02	0.05
Mantodea	0.10	0.12	0.00	0.00
Dermaptera	0.06	0.12	0.05	0.06
Blattodea	1.78	1.33	0.35	0.56
Thysanoptera	0.98	0.14	0.01	0.01
Embioptera	0.05	0.08	0.04	0.06
Siphonaptera	0.09	0.15	0.00	0.00
Mallophaga	0.12	0.28	0.00	0.00
Arachnida	3.83	1.19	1.02	0.60
Formicidae	15.68	2.79	6.76	0.74
Isopoda	2.39	1.27	0.06	0.11
Chilopoda	1.28	1.14	0.01	0.02
Diplura	0.16	0.24	0.02	0.03

*Statistically significant differences ($p<.001$) are marked with gray shade
** n=30

TABLE 2. Relationship between overall arthropod data and the olive groves' plant richness abundance (Pearson, r).

	Olive fruit fly abundance	Plant richness	Plant abundance
Ground beetle richness	-.780**	.803**	.737**
Ground beetle abundance	-.806**	.798**	.770**
Total ground arthropod abundance	-.749**	.882**	.752**
Bee richness	-.716**	.758**	.582**
Bee abundance	-.691**	.766**	.590**
Flying insect abundnance	-.673**	.658**	.663**
Olive fruit fly abundance		-.633**	-.791**
Plant richness			.726**

* n=30
** Correlation is significant at the 0.01 level (2-tailed).

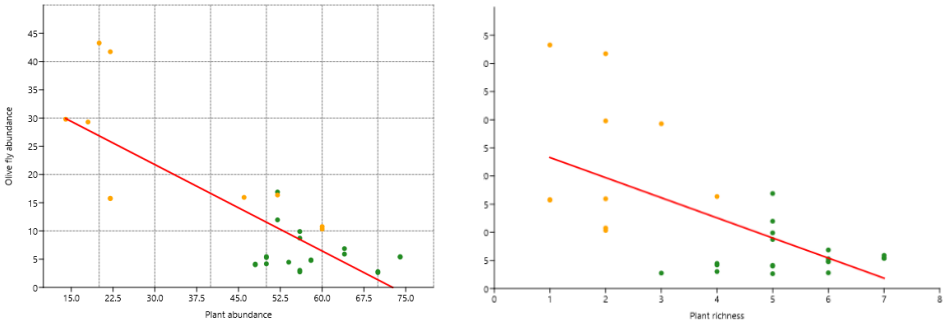

FIG. 1: Scatterplot of (A) average olive fruit fly abundance in the olive grove and the understorey plant abundance, and (B) average olive fruit fly abundance in the olive grove and the understorey plant richness.

Acknowledgments

Part of this study is funded by:

AGRICA is a research infrastructure in Greece that focuses in a holistic way on the field of agri-food to create a value chain. It was created in the context of the implementation of the "Regional Excellence" projects for research and innovation. During the period, from January 2020 to October 2023, AGRICA is financed by resources from Greece and the European Regional Development Fund with a budget of €1,178,162.65.

The implementation of the doctoral thesis was co-financed by Greece and the European Union (European Social Fund-ESF) through the Operational Programme "Human Resources Development, Education and Lifelong Learning" in the context of the Act "Enhancing Human Resources Research Potential by undertaking a Doctoral Research" Sub-action 2: IKY Scholarship Programme for PhD candidates in the Greek Universities.

References

Albertini, A., Marchi, S., Ratti, C., Burgio, G., Petacchi, R., & Magagnoli, S. (2018). Bactrocera oleae pupae predation by Ocypus olens detected by molecular gut content analysis. Biocontrol, 63 (2), 227-239. doi:10.1007/s10526-017-9860-6

Albertini, A., Pizzolotto, R., & Petacchi, R. (2017). Carabid patterns in olive orchards and woody semi-natural habitats: First implications for conservation biological control against Bactrocera oleae. Biocontrol, 62 (1), 71-83. doi:10.1007/s10526-016-9780-x

Barrientos, J. A., 1988. Basis For A Practical Entomology Course. Asociación Española de Entomología, Barcelona

Bennett, E. M., & Balvanera, P. (2007). The future of production systems in a globalized world. Frontiers in Ecology and the Environment, 5 (4), 191-198. doi:10.1890/1540-9295(2007)5[191:TFOPSI]2.0.CO;2

Biaggini, M., Consorti, R., Dapporto, L., Dellacasa, M., Paggetti, E., & Corti, C. (2007). The taxonomic level order as a possible tool for rapid assessment of arthropod diversity in agricultural landscapes. Agriculture, Ecosystems and Environment, 122 (2), 183-191. doi:10.1016/j.agee.2006.12.032

Bianchi, F. J. J. A., Booij, C. J. H., & Tscharntke, T. (2006). Sustainable pest regulation in agricultural landscapes: A review on landscape composition, biodiversity and natural pest control. Proceedings of the Royal Society B: Biological Sciences, 273 (1595), 1715-1727. doi:10.1098/rspb.2006.3530

Blaise, C., Mazzia, C., Bischoff, A., Millon, A., Ponel, P., & Blight, O. (2022). Vegetation increases abundances of ground and canopy arthropods in Mediterranean vineyards. Scientific Reports, 12 (1) doi:10.1038/s41598-022-07529-1

Castro, J., Tortosa, F. S., & Carpio, A. J. (2021). Structure of canopy and ground-dwelling arthropod communities in olive orchards is determined by the type of soil cover. European Journal of Entomology, 118, 159-170. doi:10.14411/EJE.2021.017

Chinery, M., 2005. Field Guide of Insects of Spain And Europe. Ediciones Omega, Barcelona

Daane, K. M., & Johnson, M. W. (2010). Olive fruit fly: Managing an ancient pest in modern times doi:10.1146/annurev.ento.54.110807.090553

Dindal, D. L. (1989). Soil biology guide. Soil Biology Guide

Dinis, A. M., Pereira, J. A., Pimenta, M. C., Oliveira, J., Benhadi-Marín, J., & Santos, S. A. P. (2016). Suppression of Bactrocera oleae (Diptera: Tephritidae) pupae by soil arthropods in the olive grove. Journal of Applied Entomology, 140 (9), 677-687. doi:10.1111/jen.12291

Fierer, N., Bradford, M. A., & Jackson, R. B. (2007). Toward an ecological classification of soil bacteria. Ecology, 88 (6), 1354-1364. doi:10.1890/05-1839

Hole, D. G., Perkins, A. J., Wilson, J. D., Alexander, I. H., Grice, P. V., & Evans, A. D. (2005). Does organic farming benefit biodiversity? Biological Conservation, 122 (1), 113-130. doi:10.1016/j.biocon.2004.07.018

Huqi, B., Dhima, K., Vasilakoglou, I., Keco, R., & Salaku, F. (2009). Weed flora and weed management in established olive groves in Albania. Weed Biology and Management, 9 (4), 276-285. doi:10.1111/j.1445-6664.2009.00351.x

Kakampoura, B., & Panitsa, M. (2022). Plant diversity of olive groves under different management practices: A case study on Lesbos island (East Aegean area, Greece). Flora Mediterranea, 32, 375-386. doi:10.7320/FlMedit32.375

Knapp, M., Saska, P., Knappová, J., Vonička, P., Moravec, P., Kůrka, A., & Anděl, P. (2013). The habitat-specific effects of highway proximity on ground-dwelling arthropods: Implications for biodiversity conservation. Biological Conservation, 164, 22-29. doi:10.1016/j.biocon.2013.04.012

Kubiak, K. L., Pereira, J. A., Tessaro, D., Santos, S. A. P., & Benhadi-Marín, J. (2022). The assemblage of beetles in the olive grove and surrounding Mediterranean shrublands in Portugal. Agriculture (Switzerland), 12 (6) doi:10.3390/agriculture12060771

Mantoni, C., Pellegrini, M., Dapporto, L., Del Gallo, M. M., Pace, L., Silveri, D., & Fattorini, S. (2021). Comparison of soil biology quality in organically and conventionally managed agro-ecosystems using microarthropods. Agriculture (Switzerland), 11 (10) doi:10.3390/agriculture11101022

Martínez-Núñez, C., Manzaneda, A. J., Lendínez, S., Pérez, A. J., Ruiz-Valenzuela, L., & Rey, P. J. (2019). Interacting effects of landscape and management on plant–solitary bee networks in olive orchards. Functional Ecology, 33 (12), 2316-2326. doi:10.1111/1365-2435.13465

Pe'er, G., Zinngrebe, Y., Moreira, F., Sirami, C., Schindler, S., Müller, R., Bontzorlos, V., Clough, D., Bezak, P., Bonn, A., Hansjurgens, B., Lomba, A., Mockel, S., Passoni, G., Schleyer, C., Schmidt, J., & Lakner, S. (2019). A greener path for the EU common agricultural policy. Science, 365(6452), 449-451. doi:10.1126/science.aax3146

Picchi, M. S., Bocci, G., Petacchi, R., & Entling, M. H. (2016). Effects of local and landscape factors on spiders and olive fruit flies. Agriculture, Ecosystems and Environment, 222, 138-147. doi:10.1016/j.agee.2016.01.045

Porcel, M., Cotes, B., Castro, J., & Campos, M. (2017). The effect of resident vegetation cover on abundance and diversity of green lacewings (Neuroptera: Chrysopidae) on olive trees. Journal of Pest Science, 90 (1), 195-206. doi:10.1007/s10340-016-0748-5

Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W. E. (2010). Global pollinator declines: Trends, impacts and drivers. Trends in Ecology and Evolution, 25 (6), 345-353. doi:10.1016/j.tree.2010.01.007

Simoes, M. P., Belo, A. F., Pinto-Cruz, C., & Pinheiro, A. C. (2014). Natural vegetation management to conserve biodiversity and soil water in olive orchards. Spanish Journal of Agricultural Research, 12 (3), 633-643. doi:10.5424/sjar/2014123-5255

Solomou, A., & Sfougaris, A. (2011). Comparing conventional and organic olive groves in Central Greece: Plant and bird diversity and abundance. Renewable Agriculture and Food Systems, 26 (4), 297-316. doi:10.1017/S1742170511000111

Tilman, D., Reich, P. B., Knops, J., Wedin, D., Mielke, T., & Lehman, C. (2001). Diversity and productivity in a long-term grassland experiment. Science, 294 (5543), 843-845. doi:10.1126/science.1060391

Tscheulin, T., Neokosmidis, L., Petanidou, T., & Settele, J. (2011). Influence of landscape context on the abundance and diversity of bees in Mediterranean olive groves. Bulletin of Entomological Research, 101 (5), 557-564. doi:10.1017/s0007485311000149

Vasconcelos, S., Pina, S., Herrera, J. M., Silva, B., Sousa, P., Porto, M., Melguizo-Ruiz, N., Jimenez-Navarro, G., Ferreira, S., Moreira, F., Heleno, R., Jonsson, M., & Beja, P. (2022). Canopy arthropod declines along a gradient of olive farming intensification. Scientific Reports, 12 (1) doi:10.1038/s41598-022-21480-1

Διαχείριση της βιοποικιλότητας σε ελαιώνες για την ολοκληρωμένη αντιμετώπιση των φυσικών εχθρών της ελιάς

Γ. ΣΤΑΥΡΙΑΝΑΚΗΣ[1*], S.R. STATTEGER[2], Ε. ΣΕΝΤΑΣ[1], Κ. ΤΣΑΜΑΚΔΑ[1], I. GRUMIC[1], T. TSCHEULIN[2]. ΚΑΙ ΚΙΖΟΣ Α.[1]

[1]Εργαστήριο Γεωγραφίας της Υπαίθρου και Συστημάτων Γεωργίας Ακριβείας. Τμήμα Γεωγραφίας, Πανεπιστήμιο Αιγαίου, Λόφος Πανεπιστημίου, 81100, Μυτιλήνη
[2]Εργαστήριο Βιογεωγραφίας και Οικολογίας, Τμήμα Γεωγραφίας, Πανεπιστήμιο Αιγαίου, Λόφος Πανεπιστημίου, 81100, Μυτιλήνη

ΠΕΡΙΛΗΨΗ

Η διαχείριση των φυσικών εχθρών των δενδρωδών καλλιεργειών και ιδίως των εντόμων, πραγματοποιείται συνήθως με την χρήση φυτοφαρμάκων, τα οποία μπορούν να επηρεάσουν αρνητικά την ποιότητα των προϊόντων, τους φυσικούς πόρους, τη βιοποικιλότητα, καθώς και την υγεία των παραγωγών και των καταναλωτών. Μια ανερχόμενη τάση επικεντρώνεται στη χρήση λιγότερων ή καθόλου χημικών ουσιών και στη διαχείριση των εχθρών των καλλιεργειών με φυσικά μέσα. Η τάση αυτή προωθείται από την Ευρωπαϊκή Ένωση μέσω της νέας Κοινής Αγροτικής Πολιτικής. Η καλλιέργεια της ελιάς είναι μια από τις σημαντικότερες μόνιμες καλλιέργειες στην περιοχή της Μεσογείου. Ο σημαντικότερος εχθρός στους ελαιώνες είναι ο δάκος [*Bactrocera oleae* (Rossi) (Diptera: Tephritidae)]. Στην παρούσα μελέτη διερευνούμε τη σχέση μεταξύ του πληθυσμού του δάκου και της ποικιλότητας φυτών και αρθροπόδων στον υποόροφο 15 ελαιώνων στο νησί της Λέσβου κατά τα έτη 2021 και 2022. Τα αποτελέσματα δείχνουν πως η διατήρηση αδιατάρακτου υποορόφου, ενισχύει σημαντικά τη βιοποικιλότητα των ελαιώνων και συνεπώς τις οικοσυστημικές λειτουργίες, όπως η επικονίαση, η φυσική καταπολέμηση των εχθρών και η υγεία του εδάφους.

