1 Publishable summary

The control of the vector populations is a central pillar in the overarching strategies of controlling vector-borne diseases. Indeed, this has more relevance in the case of infections caused by *Xylella fastidiosa (Xf)*, for which the lack of any effective therapy to cure infected hosts makes the control of the vectors crucial for the containment of the infections.

Surveys for potential insect vectors of *X. fastidiosa* in Europe and in particular, the Mediterranean countries, have unambiguously indicated the spittlebug (Hemiptera: Aphrophoridae) as the dominant xylem-sap feeders in olive groves.

Philaenus spumarius, a spittlebug insect*,* is polyphagous (i.e. able to feed on a various plants), is found in a wide variety of woody and herbaceous plant species and represents the most abundant Auchenorrhyncha species in the olive orchards of the contaminated areas[1,2]. As with other spittlebugs, they acquire and transmit the bacterium with a persistent modality by feeding on the xylem, or sap, of infected plants. The bacterium multiplies in the vector's foregut colonising the cuticular surface of the oral cavity. Since the transmission is not circulative, infected nymphs lose transmissibility after moulting, while this does not occur for the adults, which retain the bacterium for the entire life.

Control of this highly polyphagous species requires an integrated pest management strategy targeting the nymphal stages and the adults before they acquire the bacterium. Nymphs (five instars) survive on several herbaceous plants, weeds and groundcover where infestations are readily noticeable on plants by foamy spittle or froth they secrete for protection from desiccation, predation, and elimination of excess plant sap (Figure 1).

Control of juvenile *P. spumarius* can contribute significantly to reduce adult populations. In Apulia (southern Italy), juveniles are present on weeds from February to May-June. Previous studies[3] describing the stage-structured populations of nymphs in Apulian olive groves allowed the identification of 4th instar nymphs as the best time to apply control measures (Figure 1) to achieve the maximum efficacy.

Several studies in Italy and Spain[4,5] indicate that the only organic approaches to reduce significantly the density of the population of juveniles consist of mechanical intervention in the spring to eliminate surface weeds or the use of orange oil extract insecticide that, however, has

[1] Cornara D, Saponari M, Zeillinger A, De Stradis A, Boscia D, Loconsole G, Bosco D, Martelli GP, Almeida RPP and Porcelli F, 2014. Spittlebugs as vectors of Xylella fastidiosa in olive orchards in Italy. Journal of Pest Science 90:521-530.

[2] Ben Moussa IE, Mazzoni V, Valentini F, Yaseen T, Lorusso D, Speranza S, Digiaro M, Varvaro L, Krugner R, and D'Onghia AM, 2016. Seasonal fluctuations of sap-feeding insect species infected by Xylella fastidiosa in Apulia Olive Groves of Southern Italy. Journal of Economic Entomology, 109 (4):1512-1518.

[3] Bodino N., Cavalieri V., Dongiovanni C., Plazio E., Saladini M.A., Volani S., Gilioli G., 2019. Phenology, seasonal abundance and stage structure of spittlebug (Hemiptera: Aphrophoridae) populations in olive groves in Italy. Scientific reports, 9 (1): 1-17.

[4] Dongiovanni C, Di Carolo M, Fumarola G, Tauro D, Altamura G, Cavalieri V. 2018. Evaluation of Insecticides for the Control of Juveniles of Philaenus spumarius L., 2015–2017. Arthropod Management Tests, 43(1), 1–2 doi: 10.1093/amt/tsy073.

[5] Dáder B, Viñuela E, Moreno A, Plaza M, Garzo E, del Estal P, Fereres A 2019. Sulfoxaflor and Natural Pyrethrin with Piperonyl Butoxide Are Effective Alternatives to Neonicotinoids against Juveniles of Philaenus spumarius, the European Vector of Xylella fastidiosa. Insects 2019, 10, 225; doi:10.3390/insects10080225.

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no persistence[6] (Dongiovanni et al., 2018b). In addition, sowing *Hordeum vulgare* or *Lolium* spp. reduced the density of populations of *P. spumarius* with an efficacy ranging between 40% to 80%. But an increasing *N. campestris* population was observed in sowing plots, after two years of experimentation.

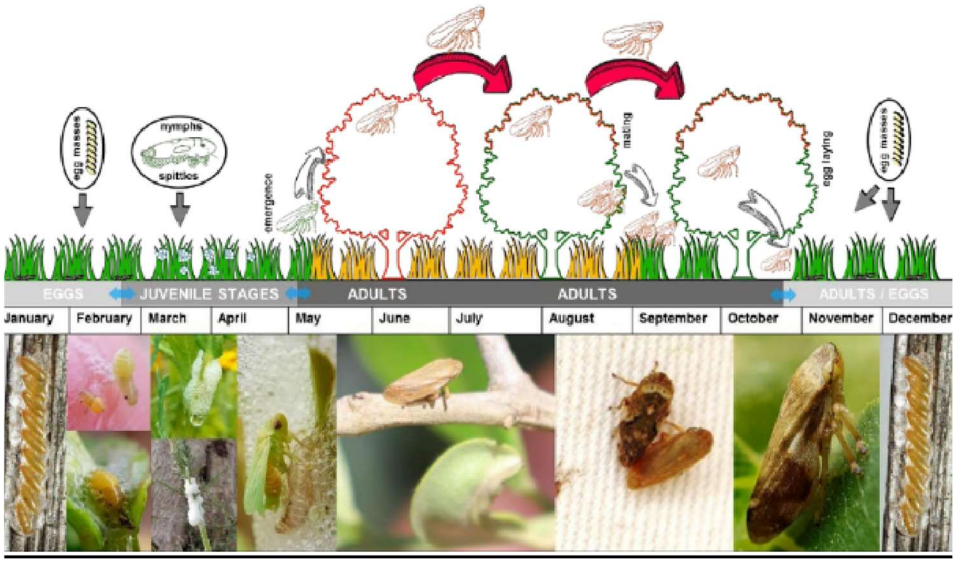

Figure 1. Biological cycle of *P. spumarius* in olive in Apulia (EFSA 2019)

Among the most effective chemical insecticides (neonicotinoids, pyrethroids, cyantraniliprole), followed by spinosine and organophosphorus, only deltamethrin is currently authorised for use on almond and in nurseries in Italy, and acetamiprid, spinetoram, phosmet, deltamethrin on olive for the control of the adults of *P. spumarius*. They all showed persistence ranging from 10 to 25 days after treatment (DAT).

Given the limited availability of effective control products in integrated and particularly in organic farming, three V-biopesticides, Glob-1, Glob-2 and Glob-3, have been tested in semi-field conditions against adult *P. spumarius* in the first year of BIOVEXO. In addition, field trials were set up in order to evaluate the effectiveness of fungal spores of an entomopathogenic strain and Glob-1 against the juvenile stages of *P. spumarius*. Preliminary results showed that some of the V-biopesticides have a prompt effect in inducing the mortality of adult stages of the insect, although their persistence is limited in comparison with chemical insecticides. While a very low efficiency was obtained against juveniles, only Glob-1 showed an effect but with inconsistent results during the different field trials.

Trials are ongoing and will be extended during the second year of project. Based on these preliminary indications, the new 2021 trials will be improved with the inclusion of repeated applications and the adoption of V-biopesticides mixture.

[6] Dongiovanni C, Altamura G, Di Carolo M, Fumarola G, Saponari M, Cavalieri V. 2018. Evaluation of Efficacy of Different Insecticides Against Philaenus spumarius L., Vector of Xylella fastidiosa in Olive Orchards in Southern Italy, 2015–17. Arthropod Management Tests, 43(1), 1–4 doi: 10.1093/amt/tsy034.

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