Vitis 49 (2), 67–70 (2010)

Evolution of the spatio-temporal distribution of *Xylotrechus arvicola* (Olivier) (Coleoptera, Cerambycidae) in La Rioja vineyard (Spain)

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Summary

***Xylotrechus arvicola* (Olivier) (Coleoptera, Cerambycidae) is a polyphagous species. Its larvae can be found feeding on different wooden cultivars and wild trees. Since 1990, this pest has become an important sanitary problem affecting vineyards in northern and central Spain (2000-2008). A study based on the distribution of the number of exit holes perforated by adults in the vinestocks was carried out for 9 years in a plot located in La Rioja wine producing region (Spain). The percentage of affected plants grew each year, from 51 % in 2004 to a level of 96 % in 2008. In 2005, dead vines began to appear with damage caused by the insect. In 2008 it increased to 17 % of the vines. This data indicated a very heavy attack of the insect which is becoming a very serious pest.**

The number of exit holes is directly related to the number of affected vinestocks and also dead plants. The spatial distribution of the holes of *X. arvicola* was studied using Taylor´s Potential Law and Iwao´s regression, as well as elaborating maps of population density. Statistical techniques indicated a uniform distribution of the pest in the sampling plot. During the cited period, several aggregation centers could be observed with a long term spatio-temporal stability using the Cramér-Von Mises test.

K e y w o r d s : aggregation centers, distribution, exit holes, maps of infestation, Tempranillo cultivar.

Introduction

The vineyard of La Rioja covers an area of about 65.000 ha. Based on the quality of its products, it constitutes the only Spanish Qualified Denomination of Origin and one of the main wine-producing regions in the world. 'Tempranillo' occupies almost 75 % of this area. It is considered the most representative autochtonous red grapevine in Spain with a heavy presence in several other Denominations of Origin (Huetz de Lemps 2009).

During the second half of the decade of 1970, in the Northen part of La Rioja, named Rioja Alta, the first symptoms of infestation caused by larvae of cerambicidae were detected inside the wood of the vinestocks at pruning time. Larvae were commonly known as the screw, due the conical outline of the preimaginal phases. Its incidence was more frequent in those plots situated in the vicinity of the rivers Oja, Tirón and Ebro rivers, because it constitutes a pest of several trees situated along river bank forests, such as *Populus*, *Salix, Ulmus,* etc. At the same time, adult exit holes, of about 4 mm in diameter, were also observed, both in the trunk of the vines as well as in the bigger branches of the vine. The identification of the coleopterans from material developed in the laboratory from samples of vine wood and captured in the field corresponded to *Xylotrechus arvicola* (Olivier) (Coleoptera, Cerambycidae), according to Ocete and del Tío (1996).

X. arvicola is a polyphagous species with a holomediterranean distribution. In Spain, it is distributed, mainly, from the North to the Central regions, and there is available data of capture in the Basque country and the Balearic Islands. Other references on the presence of this species can be found in Southern Spain, to be precise, in the Alicante and Granada provinces (Vives 1984, Bahillo 1995).

The infestated vinestocks with a traditional training *en vaso* (a kind of short pruning) or conducted on trellis exhibit rachitic shoots with a low vigour, very similar to those caused by the fungal disease Eutypa dieback. Galleries of larvae provoke a heavy reduction in production and later the death of the branches, and finally, caused the death of the plant.

In Spain, the incidence of this new sanitary problem became more intense at the beginning of the decade of 1990 due to unknown causes (Ocete and del Tío 1996). So, the pest spread to other vineyards belonging to the communities of Castilla-La Mancha, mainly on 'Cabernet Sauvignon' and 'Cencibel' ('Tempranillo'); Castilla y León, on Tinta del país ('Tempranillo') and 'Sauvignon blanc', and 'Navarra', 'Garnacha tinta', 'Tempranillo', 'Moscatel' and 'Miguel del Arco' (López *et al.* 2002, Ocete *et al.* 2002 a, c and 2004). In this last community, plantations of *Prunus spinosa*, whose berries are macerated in liquor to produce *pacharán*, a very popular distilled drink, are also being attacked intensely by this xylophagous coleopteran (Biurrun *et al.* 2007).

The level of infestation of this plague is influenced by the kind of cultivar, the pruning type and the age of the vines, according to the conclusions of several field prospections carried out in different Guarantee of Origin (A.O.C) of Castilla and León by Peláez *et al.* 2001, García

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and SÁNCHEZ 2002, ÁLVAREZ and VILLARÍAS 2003, MORENO 2005. As larvae have an endophytic development for about two years, chemical treatments with metyl-parathion, clorpyrifos, dimethoat or fipronil were unsuccessful. On the other hand, adulticide treatments are not easy to apply because the insect has an extended period of emergence. So, at present the coleopteran is increasingly becoming a serious pest in La Rioja (OCETE *et al.* 2008). Therefore the evolution of the infestation of *the screw* has been monitored over a nine year period in a plot of 'Tempranillo' situated in La Rioja Alta.

Material and Methods

S t u d y a r e a : The experimental plot has an area of 1,5 ha of 'Tempranillo' cultivar, with traditional *en vaso* training situated in the municipality of Tirgo. An annual sampling of the number of exit holes on trunks produced by adults was carried out for nine years, from 2000 to 2008. The plot was planted in 1992, with spacing of 3 x 1 m, using Richter-110 as rootstock. The first presence of exit holes caused by *X. arvicola* was observed in 1998 in a very occasional way, affecting less than 2 % of the vines. Two years later, the first rachitic shoots were detected. The vineyard was cleared in 1998 after harvest time, due to its low production of less than 2.300 kg·ha^{-1}, where an amount of 6.000 kg·ha^{-1} is allowed according to the rules of quality of the Regulating Council of La Rioja.

The main chemical treatments were carried out with fenitotrion 50 % against *Lobesia botrana* Dennis & Schiffermüller (Lepidoptera, Tortricidae), until 2004. For the control of the European red mite, *Tetranychus urticae* (Koch) (Acari, Tetranychidae), summer oils with diazinon in the bud burst period, and with pyridafenthion 40 %,15 d later. It is necessary to point out that the last winter treatment given with sodium arsenite was made in 2003.

The position of the sampling plot was 42º 32’24 ,6 ‘’ N / 002º57’17 ,5 ‘’ W, 42º32’23,7’’ N / 002º57’17,9’’ W, 42º32’27,1’’ N / 002º57’20,4 ‘’ W and 42º32’26,1’’ N / 002º57’20,8’’ W. The computation of the perforations was carried out on 100 stocks (taking 1 of each 3 vines along the same row, to a total of 10 individuals, sampling 1 row of each 3). The position of each vine was taken using a precision GPS (Topcon Lecacy-H).

On the other hand, every year, the percentage of infestation of the whole plot was calculated, taking into account data of presence/absence of symptoms in 100 vines situated on its two bigger diagonals.

S p a t i a l a n a l y s i s : The spatial distribution of the exit holes of *X. arvicola* was studied using Taylor´s Potential Law and Iwao´s regression, as well as elaborating maps of population density. The two first techniques relate the variance (s^2) and the average value (m), according the formula $s^2 = am^b$ in the first case (TAYLOR 1961 and 1984) and the formula $s^2 = (a + 1)\ m + (b - 1)\ m^2$ in Iwao´s regression (IWAO 1968). In both techniques, index *b* can be used to characterize the population’s dispersion, so inferior values to 1 would indicate that the population is distributed evenly; if it is similar to 1, the population is distributed at random. And if it is superior to 1, the population is aggregative.

Nine maps to study the evolution of the populational density were elaborated, one for every year with presence of exit holes of the cerambicide, using the program Surfer 7 (Golden software, Golden, CO, USES). The maps were compared to check the long term stability of the populations of *X. arvicola*. These comparisons were carried out using a modification of the statistical test of Cramér-Von Mises (SYRJALA 1966), with a level of significance of 5 %.

Results and Discussion

In Tab. 1 the average of infestated trunks with presence of exit holes along the period prospected is indicated. The number of perforations did not usually surpass 8/vine. The percentage of affected plants grew each year, from 51 % in 2004 to a level of 96 % in 2008. From 2005 dead vines began to appear, due to damages caused by the insect. In 2008 it increased to 17 % of the vines.

The average number of holes per vine (population density) is also shown in Tab 1. Data reflect a drastic progressive increase of this value. At the same time, it is directly related to the number of affected vines and also the number of dead plants. To corroborate these results, a regression

T a b l e 1

Average values of the infestated trunks and number of exit holes per vine in the plot (N: sample size; SE: standard error).

Year	N	Infestated trunks		Number of holes per vine	
		Average ±SE	Variance	Average±SE	Variance
2000	100	0,00±0,000	0,000	0,00±0,000	0,000
2001	100	0,05±0,022	0,048	0,05±0,022	0,048
2002	100	0,12±0,033	0,107	0,13±0,037	0,134
2003	100	0,34±0,048	0,227	0,41±0,064	0,406
2004	100	0,51±0,050	0,252	0,85±0,102	1,038
2005	98	0,69±0,047	0,215	1,43±0,124	1,505
2006	93	0,80±0,042	0,164	2,13±0,152	2,157
2007	85	0,85±0,039	0,131	2,85±0,193	3,179
2008	83	0,96±0,021	0,035	3,47±0,177	2,594

analysis between the population density and the number of dead grapevines was carried out. It shows that there is a high correlation with an adjustment to a 4th grade polynomial curve: $y = 0{,}0607 + 1{,}7445\,x - 5{,}1339\,x^2 + 4{,}4577\,x^3 - 0{,}7820\,x^4$; r = 0,9996; SE = 0,2322.

Concerning the results of the spatial study, the Taylor´s and Iwao´s indexes showed a high adjustment. In the first case, the values of *a* and *b* were 1,1625 and 0,7775, respectively, with a coefficient of correlation of 97,72 %, with a standard error of 0,2679. For the Iwao´s case, the values of *a* and *b* were 0,3908 and 0,8390, respectively, with a coefficient of correlation of 98,37, with a standard error of 0,2667. Both *b* values are smaller than 1, this fact indicates a uniform distribution of the beetle in the sampling plot.

On the other hand, maps about population density (Figs 1-3) show that the first colonization of the coleopteran settled in the eastern part of the plot. That margin was the border to another older vineyard infestated previously, while the western side ends at a hill repopulated with Cupresaceae and Pinaceae which are not hosts for this xylophagous species. The infestation moved progressively towards the north-western zone of the plot, covering almost the full plot in 2005. For this reason, in 2008 almost all grapevines are infestated (96 %).

According to data from 2003, sodium arsenite treatment had no good effectiveness for the control of larvae. It might be due to the excessive depth of the galleries excavated, where the insecticide could not impact on the targets.

In spite of the fact that spatial studies based on classic techniques of regression indicate a uniform distribution of emergence, in the maps some stable aggregation centers can be found. They are more numerous and they contain a greater level of exit holes from 2004 onwards. On the other hand, although some grouping differences are found in the different maps, the Cramér-Von Mises test (Ψ) (Tab. 2) indicates that there is a long term spatio-temporal stability. In the majority of the comparisons between different years, there were not statistically significative differences ($p < 0{,}05$). These could only be found in the first years of sampling, coinciding with those periods with a smaller density of the pest on the experimental plot.

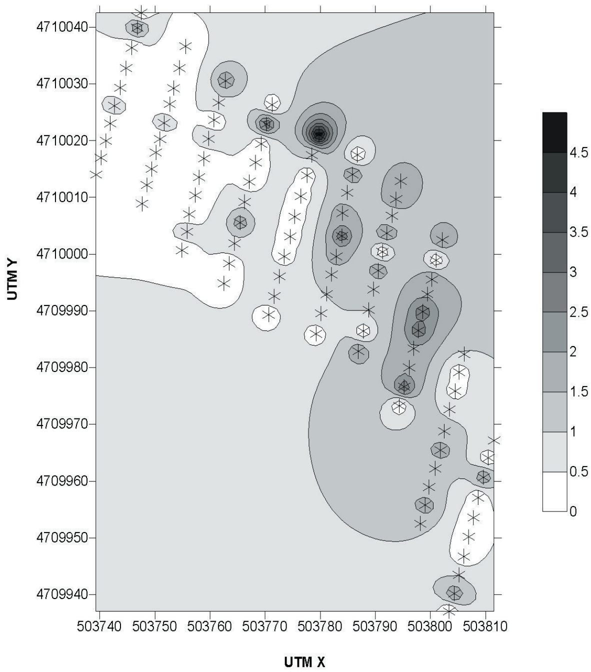

Fig. 2: Density map of *X. arvicola* exit holes in 2004 (The asterisks show the distribution of the trunks in the plot). Grey scale: number of exit holes. UTM = Universal Transverse Mercator.

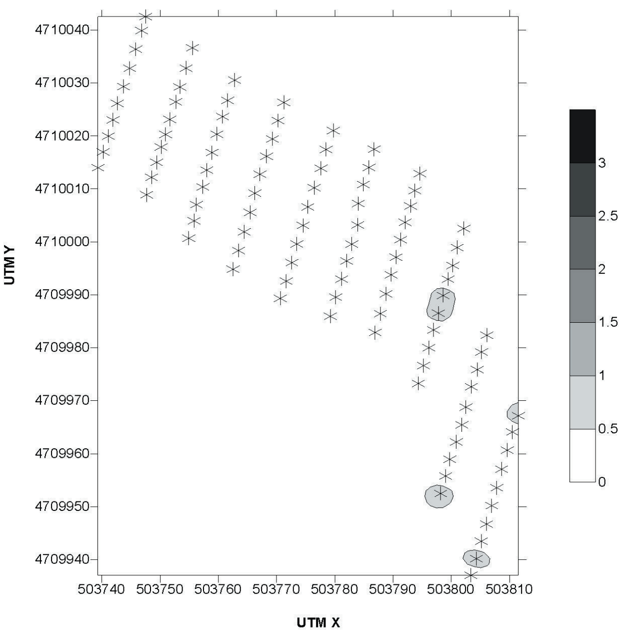

Fig. 1: Density map of *X. arvicola* exit holes in 2001 (The asterisks show the distribution of the trunks in the plot). Grey scale: number of exit holes. UTM = Universal Transverse Mercator.

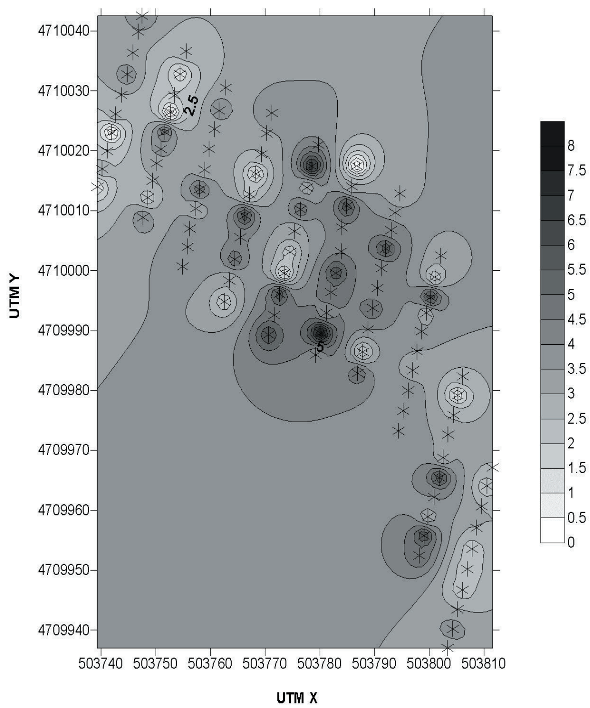

Fig. 3: Density map of *X. arvicola* exit holes in 2008 (The asterisks show the distribution of the trunks in the plot). Grey scale: number of exit holes. UTM = Universal Transverse Mercator.

Table 2

Comparison of maps with Cramér-von Mises´ bivariable test. (Ψ: statistic value; p, probability (*Significant differences)).

	Year	Ψ	P
Density of holes of *X. arvicola*	2001 vs. 2002	2,923	0,0120*
	2002 vs. 2003	0,518	0,1980
	2003 vs. 2004	0,176	0,0460*
	2004 vs. 2005	0,100	0,4280
	2005 vs. 2006	0,107	0,0800
	2006 vs. 2007	0,099	0,1190
	2007 vs. 2008	0,018	0,6490

According to data exposed in the present paper, the main conclusion is that *X. arvicola* is becoming a real serious pest in the plot studied. Its percentage of infestation grew from less than 2 % to 96 % in only nine years. This insect is mainly responsible for the subsequent death of vines. This could be accompanied by primary and secondary wood fungal diseases, as was indicated by OCETE *et al.* (2002 b) en Castilla-La Mancha vineyards.

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Received July 17, 2009