Evaluation of commercial and prototype traps for *Xylotrechus arvicola* (Coleoptera: Cerambycidae), an insect pest in Spanish vineyards

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Abstract

Background and Aims: An important factor for the success of a mass capture strategy to control cerambycids involves the selection of an effective trap–lure combination. Therefore, the aim was the evaluation of traps with lures and their efficacy for monitoring and mass trapping of *Xylotrechus arvicola.*

Methods and Results: Three trap types, Crosstrap, Delta and Screen-adhesive, with lures baited with ethanol, were evaluated during 4 years in vineyards of two cultivars. The Crosstrap obtained the greatest catches during 2013 in Tempranillo (29.6 adults/trap) and Prieto Picudo (12.9 adults/trap). All trap types showed similar periods of greatest catches in both cultivars.

Conclusions: The Crosstrap achieved the greatest number of adults captured in both cultivars. The Delta and Screen-adhesive had few catches. The Tempranillo has proved to be more susceptible to attack by this insect than Prieto Picudo. The capture period varies from 30 to 50 days in the same cultivar in different years. Low temperature during spring delays the appearance of adults.

Significance of the Study: The Crosstrap baited with ethanol captured the greatest number of *X. arvicola* adults. This trap can be used to improve monitoring of adult emergence and for controlling this pest by mass trapping.

Keywords: *lure, mass trapping, monitoring, traps,* Vitis vinifera, Xylotrechus arvicola

Introduction

Xylotrechus arvicola (Coleoptera: Cerambycidae) is a xylophagous polyphagous insect that has become a pest of vineyards in the main wine-producing regions of the Iberian Peninsula, for example, La Rioja Alta and Alavesa (Ocete and Del Tío 1996, Ocete and López 1999), Navarra (Ocete et al. 2002) and Castilla y León (Ocete and López 1999, Peláez et al. 2001). In addition, it has also been reported as a larval host on *Prunus spinosa* L. orchards (Biurrun et al. 2007). This species, in addition to the direct damage caused by the larvae, also produces indirect damage by dispersing wood fungi, which it is associated with, such as *Diplodia seriata* (De Not), *Eutypa lata* (Tul and Tul), *Phaeoacremonium aleophilum* (Gams, Crous, Wingf., Mugnai), *Phaeomoniella chlamydospora* (Crous and Gams) and *Formitiporia mediterranea* (Fisch). Attack by these fungi occurs especially in two of the main grape cultivars in Spain, Tempranillo or Cabernet Sauvignon (Ocete et al. 2002, García-Benavides et al. 2013).

Xylotrechus arvicola adults measure between 8 and 20 mm in length, the average size of the female is larger than the male, its coloration is brown or blackish and the pronotal and elytral bands are usually yellow (Moreno et al. 2003). After mating, females of *X. arvicola* lay eggs, concentrated in cracks or under the rhytidome in the vine wood. Both the fecundity and viability of eggs laid by *X. arvicola* females are extended over a long period of time (Rodríguez-González et al. 2016a). The location of the eggs enables the emerging larvae to move into the wood without any difficulty, making galleries inside the plant. The most susceptible states of the species are adults, eggs and neonate larvae, although eggs are usually protected by the rhytidome or crack. Once inserted in the wood, the larvae are inaccessible when treated with traditional foliar-applied chemicals that do not have penetrative attributes (Rodríguez-González et al. 2017a). Another problem is the treatment of *X. arvicola* adults, because they have a pattern of emergence which is staggered in time (García-Ruiz 2009). Soria et al. (2013) described the emergence period as being between late June and mid-July in the vineyards of La Rioja, extending until mid-August. Moreno (2005) described the emergence period as being from March until the end of July in vineyards of Valladolid (Castilla y León), and Biurrun et al. (2007) described the emergence period as being between 14 May and 26 August in orchards of *P. spinosa* L. in Navarra.

An integrated approach against this pest via adaptation of cultural techniques would be to remove the rhytidome (Peláez et al. 2006) and to prune the affected branches below the area of galleries (Ocete et al. 2004). These cultural measures, however, are not suitable for the indirect control of *X. arvicola* because they are expensive and not sustainable for growing (Peláez et al. 2006). The renovation of branches in vines that have been damaged is easier with the bush vines training system than in vines with bilateral cordon training systems (Rodríguez-González et al. 2016b).

Insect sex pheromones are used in pest management for monitoring and control (Witzgall et al. 2010). Monitoring of insect pests using pheromone traps can help in pest surveillance and in the forecasting of optimal timing for insecticide application (Delisle et al. 1998, Boddum et al. 2009). Mass

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trapping using pheromone traps can reduce insect pest populations, which can lead to a reduction in damage in field crops and stored products (Downham et al. 2004, El-Sayed et al. 2006, Chen et al. 2010).

In various insects, which have been described as a pest, male-produced aggregation pheromones have been identified for several *Xylotrechus* species, such as *Xylotrechus quadripes* (Chevrolat) (Hall et al. 2006), *Xylotrechus pyrrhoderus* Bates (Sakai et al. 1984), *Xylotrechus chinensis* (Chevrolat) (Kuwahara et al. 1987), *Xylotrechus colonus* (Fabricius) (Dunn and Potter 1991, Ginzel and Hanks 2005, Lacey et al. 2009, Hanks et al. 2012) and *Xylotrechus rufilius* Bates (Narai et al. 2015). The compound 3-hydroxy-2-hexanone, the corresponding 2,3-hexanediols and the homologous 8-carbon compounds are common, and often the sole pheromone components for many species in the subfamily Cerambycinae (Millar et al. 2009). This compound has been used as bait in traps to catch multiple species of subfamily Cerambycinae (Hall et al. 2007, Hanks et al. 2007, Lacey et al. 2007, Hanks and Millar 2012, Wong et al. 2012).

In previous studies, Hall et al. (2007) observed that *X. arvicola* male beetles produced the compound 3-hydroxy-2-hexanone in a wind tunnel test, where females showed attraction for males's compound (3-hydroxy-2-hexanone), but this attraction was not observed in preliminary trapping trials in the field in Spain. Rodríguez-González et al. (2017b) carried out further field testing on the compound 3-hydroxy-2-hexanone and on different designs of lures in several Spanish vineyards. Although in previous studies females showed attraction to 3-hydroxy-2-hexanone in wind tunnel tests, no attractive effects were demonstrated in field experiments again. It was showed, however, that traps baited with ethanol are highly attractive to both sexes of adults of *X. arvicola*, and these ethanol-baited traps could be used to improve monitoring of the appearance of adult beetles, and perhaps even to reduce their populations by mass trapping.

Attraction of beetles to ethanol is by no means unprecedented and other cerambycids have been attracted by combinations of pheromones and host-plant volatiles, including ethanol (Allison et al. 2012, Hanks et al. 2012, Hanks and Millar 2012, Miller et al. 2015). *Xylotrechus* species are reported to be attracted to stressed and weakened plants (Hanks 1999) and it is likely that these would produce ethanol. Ethanol emissions have been shown to increase in trees after a stress event (Kimmerer and Kozlowski 1982, Gara et al. 1993, Kelsey 1994, Kelsey and Joseph 2003, Kelsey et al. 2014). Miller et al. (2015) also reported that ethanol increased the proportion of traps detected by the cerambycid species *Neoclytus scutellaris* (Olivier), *Neoclytus acuminatus* (Fabricius), *Eburia quadrigeminata* (Say), *Elaphidion mucronatum* (Say), *X. colonus* and *Curius dentatus* Newman.

The aim of this study was to evaluate more trap types for improvement in the capture of this pest and to advance knowledge of the methodology of monitoring and mass trapping of this pest, once a bait to attract *X. arvicola* adults (ethanol) and a dispenser for the lure (polyethylene bags) were found.

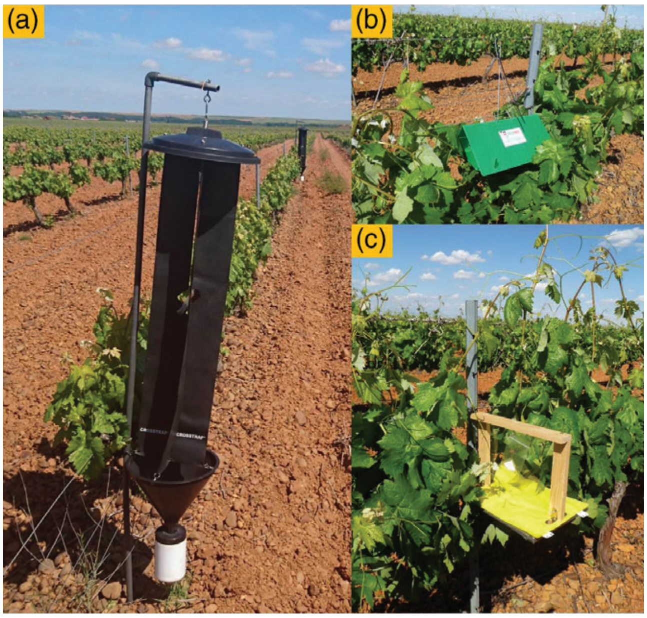

Figure 1. Traps evaluated for trapping *Xylotrechus arvicola* adults: (a) Crosstrap, (b) Delta trap and (c) Screen-Adhesive trap.

Materials and methods

Lures

The lures used in this experiment were contained inside low-density polyethylene bags (95 mm × 60 mm × 50 µ thick; Transpack, Southampton, England) with a press seal. Ethanol (Ethanol Absolute; VWR Chemicals Prolabo, Fontenay-sous-Bois, France) (1 mL) was impregnated onto a cotton dental roll (a cylindrical mass of purified and sterilised cotton used as packing or absorbent material in various dental procedures) (35 × 8 mm; Kent Express Dental Supplies, Gillingham, England), which had previously been placed inside each polyethylene bag.

Trap types

Three traps were evaluated. (i) Crosstrap (Econex, Murcia, Spain) (Figure 1a) consists of a polypropylene lid, 33 cm in diameter with a central carabiner attached to a steel spring. Two reinforced PVC sheets (80.0 × 30.0 cm^2) are held in place by four steel springs in the upper section of the lid. In the lower section, the reinforced PVC sheets are held in place by a polypropylene funnel, 30 cm in diameter and four steel springs. The collection cup for the captured insects is in the lower section of the funnel. The dry collection cup (12.5 cm diameter × 19 cm height) is provided with a stainless steel mesh that drains away rainwater (Econex 2017). All panels were coated with Fluon (Dyneon, 3M, Berkshire, England) as recommended by Graham et al. (2010). Lures were attached to the trap at the midway point and insects were trapped in a receiver at the base. (ii) Delta Trap (Econex) (Figure 1b), green in colour, is formed by two panels in a roof-like shape (15 × 28 cm) on a base with two side windows for insects to penetrate inside. Traps had a 20 by 20 cm base and a 3 cm flap at each opening of the trap. The area of the opening was 65.8 cm^2. All traps had white sticky liners (18.5 by 19.5 cm) that were inserted over the base of the trap, coated with 10.0 g Tangle-trap adhesive (Econex). Lures were hung inside the trap at the center of the top ridge of the trap to provide a protection for the lure. (iii) Screen-adhesive trap (University of León, León, Spain) (Figure 1c), in wood colour, is composed by a vertical panel (20 cm) joined in the middle to a horizontal panel (30 cm). The vertical panel is formed by a transparent, slippery surface and with a 4 cm^2 hole perforated in the center of the panel. The horizontal panel had two yellow sticky liners (10 by 30 cm) that were placed over the base of the trap (horizontal panel), coated with 10 g Tangle-trap adhesive (Econex). Lures were hung in the middle of the trap, at the center of the vertical panel of the trap to provide a greater dissemination of the lure. At the time of the experiment, this trap model was a non-commercial prototype provided by the Research Group in Engineering and Sustainable Agriculture of the University of León for testing against insect pests.

The Crosstrap was selected as the reference trap because this type of trap had been widely used for the control of other cerambycids [*Monochamus galloprovincialis* (Olivier)], described as a plague in woody crops (*Pinus* spp.) from several countries (Álvarez et al. 2015), and because, it was the trap type that had been used in the previous tests for the evaluation in the field of the compounds 3-hydroxy-2-hexanone and ethanol as attractants of *X. arvicola* adults (Rodríguez-González et al. 2017b). The Delta trap was chosen because it has also been used to capture and control other insects whose larvae are wood borers, *Synanthedon scitula* Harris (Lepidoptera: Sesiidae) (Zhang et al. 2013), or insect pests that also affect the vineyard and whose larvae are fruit borers, *Lobesia botrana* Denis & Schiffermüller (Lepidoptera: Tortricidae) (Rayegan et al. 2016) or *Paralobesia viteana* Clemens (Lepidoptera: Tortricidae) (Dong et al. 2013). The Screen-adhesive trap prototype was designed according to the behaviour of adults in the vineyard and has been described by other authors. García-Ruiz (2009) noted that *X. arvicola* adults move between vegetation and flowers in vineyards and they also have the ability to undertake short flights that may be longer when taking advantage of air currents (Peláez et al. 2006). The Screen-adhesive trap consists in a transparent vertical panel which the insects can collide into and then adhere to its base, making for a good system to catch this insect in vineyards.

Study site

This experiment was executed between June and July, from 2013 until 2016, in two vineyards, with the cvs Tempranillo and Prieto Picudo, located in Gordoncillo (42°08′14.9″N, 5°25′41.6″W) (León, Castilla y León, Spain). The vineyards were chosen on the basis of the presence of *X. arvicola* damage, such as larval galleries inside the plants and exit holes of *X. arvicola* adults on trunks and branches of vines. These vineyards were planted uniformly with the two cultivars chosen. Vines were spaced 3.0 × 1.5 m between the rows and vines, respectively. Vineyards were surrounded by other vineyards. The two vineyards had the same characteristics in terms of age (18 years old), training system of vines (bilateral cordon, spur pruning over two branches per trunk at 0.6 m above the ground), soils (calcareous soils, low in minerals and poor in organic matter), height above sea level (747 m), annual average temperature (11.7°C) and average rainfall (500 mm).

In the Tempranillo vineyard, an area of 0.7 ha (72 m length × 108 m width) was divided into nine blocks of 0.03 ha, each containing four trap–lure combinations giving a total of 12 traps in this vineyard. In the Prieto Picudo vineyard, an area of 0.5 ha (72 m length × 72 m width) was divided into four blocks of 0.03 ha, each containing four trap–lure combinations giving a total of eight traps in this vineyard. Lures (polyethylene bags baited with 1 mL of ethanol) were changed every 10 days during the course of the experiment.

Crosstraps were first attached to a 1.5 m PVC pipe, hanging the trap out of an L-shaped arm. The Delta traps and Screen-adhesive traps were hung with a wire hanger in the trellis (steel wire) on which the vines are trained, at 1.2 m above the ground level, with a distance of 18 m between each trap. The distribution of all traps in each block was randomised. All traps were monitored every 2 or 3 days and captured insects were identified and sexed in the laboratory, according to the description of Moreno (2005). The position of traps was not rotated during the 8 weeks evaluation. For analysis, the capture results were calculated as beetles per trap and day. In each cultivar and year, the catch results were gathered into ranges of 10 days, a similar time period to when lures were renewed.

Statistical analysis

Means values were transformed to $\log(x + 1)$ to normalise the variances and subjected to ANOVA. Means of males and females captured per trap in the same cultivar and year were normally distributed and subjected to one-way ANOVA. In all cases, means separation was conducted using Fisher's least significant difference. All analyses were performed using the SAS version 9.1.2 software (SAS Institute, Cary, NC, USA).

Results

Captures by trap type and time (range of days)

The Delta traps in Prieto Picudo had a greater number of adults captured from 1 to 10 July 2014, and from 11 to 20 July 2016, than that captured by Crosstraps during the same time periods; however, there was no significantly difference between these traps (Table 1).

Crosstraps in the remainder of the ranges of days and years had the greatest number of adults captured in both cultivars, being significantly different from the other trap types (Table 1).

Screen-adhesive traps, during the year 2013, captured only an average of 0.3 insects (from 11 to 20 July) in Tempranillo. These few captures were significantly different from that of the other traps during the same range of days and for the same cultivar. These observations showed this prototype trap was ineffective and was ruled out for following years (Table 1).

Annual captures by trap type

Crosstraps in Tempranillo obtained the highest number of captures during the year 2013 (29.6 adults/trap). This trap type in Prieto Picudo also obtained the highest annual number of captures during the year 2013 (12.9 adults/trap) (Table 1).

Delta traps also had a behaviour similar to that described for Crosstraps in the two cultivars and during the years, but with a lower annual number of catches. In Tempranillo, these traps obtained the highest number of captures during the year 2013 (3.3 adults/trap). In Prieto Picudo, this trap type also obtained the greatest number of captures in the year 2013 (1.8 adults/trap) (Table 1).

Annual captures (males and females) obtained in all trap types in different ranges of days and cultivars

During the year 2013, in Tempranillo, adults were captured from 21 June to 20 July, with the greatest annual number of captures obtained from 1 to 10 July (7.3 adults/trap), which was significantly different from that obtained in the

Table 1. Adults of *Xylotrechus arvicola* captured every 10 days by three traps, Crosstrap, Delta and Screen-adhesive, lured with ethanol, in 2-month field trials, over 4 years, in vineyards located in Gordoncillo, Spain.

		Mean number of adults captured ± SE						
Cultivar	Trap type	1–10 June†	11–20 June	21–30 June	1–10 July	11–20 July	21–31 July	∑, Total
2013								
Tempranillo	Crosstrap	–	–	4.5 ± 0.7a	20.4 ± 2.2a	4.5 ± 0.7a	–	29.6 ± 2.7a
	Delta	–	–	0.4 ± 0.1b	1.8 ± 0.4b	1.1 ± 0.4b	–	3.3 ± 0.6b
	Screen-adhesive	–	–	0.0 ± 0.0c	0.0 ± 0.0c	0.3 ± 0.1c	–	0.3 ± 0.1c
Prieto Picudo	Crosstrap	–	–	1.3 ± 0.4a	8.6 ± 1.6a	2.7 ± 0.3a	0.3 ± 0.1a	12.9 ± 1.8a
	Delta	–	–	0.0 ± 0.0b	0.8 ± 0.3b	0.8 ± 0.3b	0.3 ± 0.1a	1.8 ± 0.5b
	Screen-adhesive	–	–	0.0 ± 0.0b	0.0 ± 0.0c	0.0 ± 0.0c	0.0 ± 0.0b	0.0 ± 0.0c
2014								
Tempranillo	Crosstrap	–	9.0 ± 1.3a	2.2 ± 0.5a	0.1 ± 0.1a	–	–	11.3 ± 1.3a
	Delta	–	0.3 ± 0.1b	0.3 ± 0.1b	0.1 ± 0.1a	–	–	0.8 ± 0.2b
Prieto Picudo	Crosstrap	–	6.7 ± 1.0a	4.1 ± 0.9a	0.0 ± 0.0ab	–	–	10.9 ± 1.5a
	Delta	–	0.5 ± 0.2b	0.1 ± 0.1b	0.2 ± 0.2a	–	–	0.9 ± 0.2b
2015								
Tempranillo	Crosstrap	1.6 ± 0.4a	0.5 ± 0.2a	4.0 ± 0.6a	0.8 ± 0.3a	–	–	6.8 ± 0.8a
	Delta	0.2 ± 0.1b	0.0 ± 0.0b	0.3 ± 0.1b	0.2 ± 0.1b	–	–	0.5 ± 0.1b
Prieto Picudo	Crosstrap	1.5 ± 0.4a	0.5 ± 0.2a	5.1 ± 0.8a	1.3 ± 0.3a	–	–	8.3 ± 1.1a
	Delta	0.3 ± 0.2b	0.0 ± 0.0b	0.1 ± 0.1b	0.3 ± 0.2b	–	–	0.6 ± 0.3b
2016								
Tempranillo	Crosstrap	0.5 ± 0.2a	0.5 ± 0.2a	7.6 ± 1.5a	3.6 ± 0.7a	1.1 ± 0.4a	–	14.1 ± 0.8a
	Delta	0.0 ± 0.0b	0.0 ± 0.0b	0.1 ± 0.1b	0.0 ± 0.0b	0.0 ± 0.0b	–	0.2 ± 0.1b
Prieto Picudo	Crosstrap	0.8 ± 0.2a	1.9 ± 0.5a	6.0 ± 0.9a	3.1 ± 0.6a	0.0 ± 0.0ab	–	11.8 ± 1.8a
	Delta	0.3 ± 0.1b	0.0 ± 0.0b	0.0 ± 0.0b	0.6 ± 0.3b	0.2 ± 0.2a	–	1.1 ± 0.4b

†Means followed by different lower-case letters in the same range of days (10 days), cultivar and year were significantly different between traps (ANOVA, LSD, $P < 0.05$). –, No insect was captured in the traps at this time period; LSD, least significant difference.

other ranges of days. In addition, in Prieto Picudo, the capture period also began on 21 June, but lasted until 31 July. The period of greatest capture also occurred from 1 to 10 July, differing significantly from annual captures obtained in the remaining ranges of days (Table 2).

In the year 2014, in Tempranillo and Prieto Picudo, adults were captured from 11 June to 10 July, with the greatest annual captures obtained since 11–20 June (4.6 and 3.6 adults/trap, respectively, in each cultivar), significantly different from captures obtained in the other ranges of days in Tempranillo. In Prieto Picudo, the greatest capture period (11–20 June) differed significantly only from the captures obtained since1–10 July (Table 2).

In all traps evaluated during the year 2015, captures occurred from 1 June to 10 July in Tempranillo and Prieto Picudo. The greatest annual capture period was from 21 to 30 June (2.1 and 2.6 adults/trap in Tempranillo and Prieto Picudo, respectively). The values obtained in both cultivars were significantly different from the captures obtained in the other ranges of days evaluated (Table 2).

Finally, in the year 2016 in both cultivars, adults were captured from 1 June to 20 July. Similar to what was described in 2015, the greatest annual capture period occurred between 21 and 30 June (3.8 and 3.0 adults/trap in Tempranillo and Prieto Picudo, respectively). It was significantly different from the captures obtained in the other ranges of days evaluated in both cultivars (Table 2).

Sex of adults captured in different range of days and cultivars

The range of days for Tempranillo when the greatest capture of males and females was obtained was: from 1 to 10 July (3.3 males/trap and 4.0 females/trap, respectively) in 2013; from 11–20 June (2.6 males/trap and 2.0 females/trap) in 2014; and from 21–30 June in 2015 and 2016 (with 1.2 males/trap and 0.9 females/trap, and 1.2 and 2.6 females/trap, respectively). In each sex, these captures differed significantly from the captures obtained in the other ranges of days evaluated within the same year and cultivar. In the range of days of each year when the greatest captures were achieved, there was no significant difference between the sexes. There was only a significant difference between the 1.2 males/trap and 2.6 females/trap captured from 21–30 June in 2016 (Table 2).

The range of days for Prieto Picudo of greatest capture of males and females was similar to that described in Tempranillo. The captures were 1.1 males/trap and 2.0 females/trap in 2013, 2.1 males/trap and 1.5 females/trap in 2014, 1.5 males/trap and 1.1 females/trap in 2015 and 1.5 males/trap and 1.5 females/trap in 2016. For each sex, all these captures differed significantly from the captures obtained in the other ranges of days evaluated within the same year and cultivar. In the range of days of each year in which the greatest captures were obtained, there was no significant difference between sexes (Table 2).

Discussion

In the present study, the Crosstrap type captured the highest number of adults of *X. arvicola* in both cultivars during the 4 years. These results could be due to three reasons: (i) this trap has a larger surface where *X. arvicola* adults are intercepted; (ii) air currents and the flexible trap panels allow a greater diffusion of the bait around the vineyard; and/or (iii) panels of this trap were treated with Fluon (Northern Products, Woonsocket, RI, USA), which favours intercepted insects to slip and fall into the container. In addition, Graham et al. (2010) considered that the trap's panels treated

Table 2. Males and females of *Xylotrechus arvicola* captured every 10 days by three traps lured with ethanol, in 2-month field trials, over 4 years, in vineyards located in Gordoncillo, Spain.

		Mean number of males and females captured ± SE					
Cultivar	**Sex**	**1–10 June†'‡**	**11–20 June**	**21–30 June**	**1–10 July**	**11–20 July**	**21–31 July**
2013							
Tempranillo	♂	0.0 ± 0.0aD	0.0 ± 0.0aD	0.4 ± 0.1bC	3.3 ± 0.7aA	1.5 ± 0.3aB	0.0 ± 0.0aD
	♀	0.0 ± 0.0aD	0.0 ± 0.0aD	1.2 ± 0.3aB	4.0 ± 1.0aA	0.4 ± 0.1bC	0.0 ± 0.0aD
	Total	0.0 ± 0.0C	0.0 ± 0.0C	1.6 ± 0.4B	7.3 ± 1.7A	1.9 ± 0.4B	0.0 ± 0.0C
Prieto Picudo	♂	0.0 ± 0.0aC	0.0 ± 0.0aC	0.1 ± 0.1aCD	1.1 ± 0.3aA	0.6 ± 0.2aB	0.1 ± 0.1aC
	♀	0.0 ± 0.0aD	0.0 ± 0.0aD	0.3 ± 0.2aC	2.0 ± 0.7aA	0.5 ± 0.1aB	0.1 ± 0.1aCD
	Total	0.0 ± 0.0D	0.0 ± 0.0D	0.4 ± 0.2C	3.1 ± 0.9A	1.1 ± 0.3B	0.2 ± 0.1C
2014							
Tempranillo	♂	0.0 ± 0.0aC	2.6 ± 0.7aA	0.6 ± 0.2aB	0.0 ± 0.0aC	0.0 ± 0.0aC	0.0 ± 0.0aC
	♀	0.0 ± 0.0aC	2.0 ± 0.4aA	0.6 ± 0.2aB	0.1 ± 0.1aC	0.0 ± 0.0aC	0.0 ± 0.0aC
	Total	0.0 ± 0.0C	4.6 ± 1.1A	1.2 ± 0.3B	0.1 ± 0.1C	0.0 ± 0.0C	0.0 ± 0.0C
Prieto Picudo	♂	0.0 ± 0.0aC	2.1 ± 0.6aA	1.1 ± 0.4aAB	0.1 ± 0.1aC	0.0 ± 0.0aC	0.0 ± 0.0aC
	♀	0.0 ± 0.0aC	1.5 ± 0.5aA	1.0 ± 0.3aAB	0.1 ± 0.1aC	0.0 ± 0.0aC	0.0 ± 0.0aC
	Total	0.0 ± 0.0C	3.6 ± 1.0A	2.1 ± 0.7AB	0.1 ± 0.1C	0.0 ± 0.0C	0.0 ± 0.0C
2015							
Tempranillo	♂	0.3 ± 0.1aB	0.1 ± 0.1aBC	1.2 ± 0.3aA	0.3 ± 0.1aB	0.0 ± 0.0aC	0.0 ± 0.0aC
	♀	0.6 ± 0.2aB	0.2 ± 0.1aC	0.9 ± 0.3aA	0.1 ± 0.1aCD	0.0 ± 0.0aD	0.0 ± 0.0aD
	Total	0.9 ± 0.3B	0.3 ± 0.1C	2.1 ± 0.5A	0.4 ± 0.1C	0.0 ± 0.0D	0.0 ± 0.0D
Prieto Picudo	♂	0.2 ± 0.1bC	0.1 ± 0.1aCD	1.5 ± 0.5aA	0.5 ± 0.1aB	0.0 ± 0.0aD	0.0 ± 0.0aD
	♀	0.7 ± 0.3aAB	0.1 ± 0.1aCD	1.1 ± 0.3aA	0.3 ± 0.1aC	0.0 ± 0.0aD	0.0 ± 0.0aD
	Total	0.9 ± 0.3B	0.2 ± 0.1C	2.6 ± 0.7A	0.8 ± 0.2B	0.0 ± 0.0D	0.0 ± 0.0D
2016							
Tempranillo	♂	0.1 ± 0.1aCD	0.2 ± 0.1bC	1.2 ± 0.2bA	0.7 ± 0.2aB	0.2 ± 0.1aC	0.0 ± 0.0aD
	♀	0.1 ± 0.1aDE	0.5 ± 0.1aC	2.6 ± 0.7aA	0.9 ± 0.2aB	0.2 ± 0.1aD	0.0 ± 0.0aE
	Total	0.2 ± 0.1D	0.7 ± 0.2C	3.8 ± 0.9A	1.6 ± 0.4B	0.5 ± 0.2CD	0.0 ± 0.0E
Prieto Picudo	♂	0.1 ± 0.1bCD	0.1 ± 0.1bCD	1.5 ± 0.5aA	1.1 ± 0.3aAB	0.0 ± 0.0aD	0.0 ± 0.0aD
	♀	0.4 ± 0.1aC	0.8 ± 0.3aB	1.5 ± 0.3aA	0.7 ± 0.2aBC	0.1 ± 0.1aD	0.0 ± 0.0aD
	Total	0.5 ± 0.1C	0.9 ± 0.3C	3.0 ± 0.8A	1.8 ± 0.4B	0.1 ± 0.1D	0.0 ± 0.0D

†Means followed by different lower-case letters in the same range of days (10 days), cultivar and year were significantly different between sexes (ANOVA, LSD, $P < 0.05$). ‡Means followed by different capital letters in the same cultivar and year were significantly different among the range of days (10 days) (ANOVA, LSD, $P < 0.05$). LSD, least significant difference.

with Fluon increased the catches. Moreover, if traps are treated with Fluon, captured insects will not escape from it, thus increasing the effectiveness of traps (Álvarez et al. 2015).

In contrast, while captured insects in Delta and Screen-adhesive traps die within a few hours, in Crosstrap they stay alive in the container. These live insects can be taken to the laboratory for further research into their biology (Rodríguez-González et al. 2016a), morphological or biometric studies (Rodríguez-González et al. 2016b) or for evaluating different insecticides on different stages of the insect's development (Rodríguez-González et al. 2016c).

In all trap types evaluated the greatest catches with both cultivars occurred during the first year (2013). It is probable that after this first year, there was a decrease in the population of this pest and therefore smaller catches were obtained in the following years, with this effect combined with the pruning of infested wood during successive years (Mr Esteban Sanchez-Maillo, unpublished data, 2014).

The number of catches of insects in each trap for Tempranillo was greater than that obtained in Prieto Picudo in all years when the traps were evaluated. This could indicate that Tempranillo has a greater susceptibility to attack by this insect, and it is more susceptible to it than Prieto Picudo. Previous studies (Ocete and Del Tío 1996, Moreno et al. 2004) confirm the results of our study and, as a novelty, we have shown that the Prieto Picudo is also sensitive to attack by *X. arvicola*, but with a lower incidence. Peláez et al. (2006) reported that Tempranillo, Viura and Cabernet Sauvignon cultivars have the highest incidence or proportion of affected strains (cultivars with low holocellulose and high lignin content), compared to cv. Mencia where the proportion of attacks is lower (cultivar with low lignin content and high holocellulose).

The timing of the appearance of the adults of this pest in the vineyard varies greatly between years. The period of adult catches occurred during 30 days in 2014 (from 11 June–10 July), reaching 50 days in 2016 (from 1 June–20 July). The explanation according to Peláez et al. (2006) and García-Ruiz (2009), who have similar results, is that this pest has a staggered and/or prolonged emergence period over time.

Moreover, Peláez et al. (2006) added that the appearance of adults in vineyards may be delayed with a higher concentration of adults in a few days if the spring has been cold. Climatic data obtained (Inforiego 2016) from the nearest weather station to the trial plots (Mayorga de Campos, Valladolid, Spain), recorded an average temperature of 10.62°C for spring 2013, which was cooler than those obtained in 2014 (13.36°C), 2015 (13.61°C) and 2016 (11.69°C). These data confirm what happened with the catches produced during the year 2013 in our trial compared to that of the other years evaluated: the delay in the appearance of insects in the vineyard (until 21 June, there were no first catches), and the concentration of catches in a few days.

The capture periods of insects in our trial ran between 1 June and the middle of July, varying this period between years within the same cultivar. This range of dates obtained in our trial falls within the emergency dates of this insect described by other authors in other areas and crops, such as Soria et al. (2013), who described the period between late June and mid-July in vineyards of La Rioja; or Moreno (2005), who described the period from March until the end of July in vineyards of Valladolid (Castilla y Leon); or Biurrun et al. (2007), who described the period between 14 May and 26 August in *P. spinosa* L. orchards in Navarra.

García-Ruiz (2009) pointed out that during the emergence of adults in the field, there is a greater presence of males than females in the first few days. In the area and with the cultivars evaluated in our trial, a greater presence of males during the first days of catches was observed only in 2014 in both cultivars. In the remaining years, there was a greater presence of females during the first days of catches with both cultivars.

In conclusion, the greatest number of *X. arvicola* adults captured in both cultivars was achieved by the Crosstrap baited with ethanol, whose panels treated with Fluon favoured intercepted insects to slip and fall into the container. Delta and Screen-adhesive traps baited with ethanol had few catches, and furthermore insects captured died in a few hours. In all trap types evaluated in both cultivars, the greatest number of catches occurred during the year 2013. In Tempranillo, the greatest number of insects was captured, according to the greater susceptibility of Tempranillo than Prieto Picudo as indicated by other authors. This pest is variable in the timing of the adult appearance in vineyards, with the capture period varying from 30 to 50 days. Low temperature during the spring delays the appearance of adults in vineyards. The capture periods in vineyards of this area run between the 1 June and the middle of July, with a greater presence of females during the first few days. Since Crosstrap captured the greatest number of insects in both cultivars during all years, this type of trap can be used to improve monitoring of adult emergence and for controlling this pest by mass trapping.

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