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**INFLUENCE OF DIFFERENT TRAP FEATURES IN THE CAPTURES OF
RHYNCHOPHORUS FERRUGINEUS OLIVIER (COLEOPTERA: DRYOPHTHORIDAE)
ADULTS**

J. A. ÁVALOS⁽¹⁾ and A. SOTO⁽¹⁾

⁽¹⁾Instituto Agroforestal Mediterráneo, Universitat Politècnica de València, Camí de vera s/n,
46022 Valencia, Spain. Email: asoto@eaf.upv.es

SUMMARY

Rhynchophorus ferrugineus Olivier (Coleoptera: Dryophthoridae) remains currently the most important palm pest around the Mediterranean Basin, and probably in the world. Olfactive traps to capture Red Palm Weevil (RPW) adults are used in an integrated pest management. This method is applied both for monitoring and for mass trapping. In Spain are used different pheromone trap models, with different external characteristics. The aim of this study was to compare the efficacy of different RPW trap features, such as colour and shape, to improve the RPW adult captures of this method. The trial was carried out in Torrente (Valencia, Spain) between September and December 2010, in the surrounding areas of a *Phoenix canariensis* hort. ex Chabaud orchard. Bucket traps with black colour capture double RPW adults than pyramidal traps with other colours.

Key words: *Rhynchophorus ferrugineus*, bucket trap, colour, shape, pyramidal trap.

RÉSUMÉ

INFLUENCE DES DIFFÉRENTES CARACTÉRISTIQUES DE PIÈGES SUR LES CAPTURES DES ADULTES DE *RHYNCHOPHORUS FERRUGINEUS* OLIVIER (COLEOPTERA : DRYOPHTHORIDAE)

Rhynchophorus ferrugineus Olivier (Coleoptera: Dryophthoridae) est actuellement le plus important ravageur des palmiers autour du bassin méditerranéen, et probablement dans le monde. Les pièges olfactifs pour attraper les adultes du charançon rouge du palmier (CRP) sont utilisés dans la gestion intégrée de ce ravageur. Cette méthode est appliquée à la fois pour la surveillance et le piégeage de masse. En Espagne, différents modèles de pièges à phéromones sont utilisés, avec différentes caractéristiques externes. Le but de cette étude a été de comparer l'efficacité des différentes caractéristiques des pièges à CRP, comme la couleur et la forme, pour améliorer les captures des adultes du CRP avec cette méthode. L'étude a été menée à Torrente (Valence, Espagne) entre septembre et décembre 2010, dans les environs d'une pépinière de *Phoenix canariensis* hort. ex Chabaud. Les pièges de type "seau de couleur noire" capturent deux fois plus d'adultes de CRP que les pièges pyramidaux d'autres couleurs.

Mots-clés: *Rhynchophorus ferrugineus*, piège seau, couleur, forme, piège pyramidal.

INTRODUCTION

The red palm weevil (RPW), *Rhynchophorus ferrugineus* Olivier (Coleoptera: Dryophthoridae), is still the most invasive and destructive pest of palm trees in the world. Native from the southern Asia and Melanesia, during the mid 1980s it invaded the Middle Eastern and in 1992 arrived to North Africa (COX, 1993; ABRAHAM *et al.*, 1998). In Europe it was detected the first time in Spain, in 1993 (BARRANCO *et al.*, 1996). In 2006 his presence was reported in France, and from this time on, the pest has spread in almost all the countries of the Mediterranean Basin (EPPO, 2008, 2009a, 2009b). The insect is also arrived to the American continent, being detected in 2009 in Curaçao Island, in the Dutch Antilles, and in 2010 in the state of California, in the USA (EPPO, 2009b, 2010).

R. ferrugineus has a wide host range, affecting species of 16 different genera (BARRANCO *et al.*, 2000), but in the Mediterranean Basin attack principally date palms (*Phoenix dactylifera* L.) and canary island date palms (*Phoenix canariensis* hort. ex Chabaud) (COX, 1993; BARRANCO *et al.*, 1996). The RPW larval stages feed within the trunk and generally destroy the apical growth area, frequently causing the death of the palm (MURPHY & BRISCOE, 1999). Symptoms of attack are distinctive but generally are detected after the palm has been seriously damaged (BLUMBERG, 2008; MALUMPHY & MORAN, 2009).

Palm trees are generally used with an ornamental purpose and are part of the culture and traditions of many cities and towns around the Mediterranean Sea. To preserve it, different preventive and curative methodologies should be applied. Quarantine regulations, to prevent the spread of the RPW to countries free of the pest (BLUMBERG, 2008). Employment of different chemical pesticides, through aerial spraying, soil applications or trunk injections (FALEIRO, 2006). The use of entomopathogenic nematodes is an alternative method to the use of chemical insecticides (ABBAS & HANONIK, 1999). Other methodologies are the prompt destruction of infested plants (EPPO, 2008), the vegetal surgery (LA MANTIA *et al.*, 2008) and the knowledge of the initial symptomatology. Finally, the aggregation-pheromone traps, used for monitoring and reduce RPW populations (HALLET, 1999). Because of the quantity of chemical pesticides released to the environment is excessive, should be promoted the use of environmentally benign control methods. The use of trapping systems reduce the quantity of applied pesticides (EL SAYED *et al.*, 2006). In Spain are used different trap models, with different external features like colour or shape, to capture RPW. A lot of works analyzed the trap design and the colour attraction to RPW adults, obtaining different results (HALLET *et al.*, 1999; FALEIRO, 2005; SANSANO *et al.*, 2008; ALFARO *et al.*, 2011).

The aim of this work was to compare different RPW trap models to know which external characteristics can allow to improve the effectiveness of the trapping system.

MATERIAL AND METHODS

The study was conducted between September and December 2010, coinciding with the peak period of RPW flight (ÁVALOS & SOTO, 2011). Different palm tree orchards of a nursery in Torrente (eastern Spain) (latitude: 39° 25' 37"n; longitude: 00° 27' 26" w; altitude: 17 m) were used. All of them had high infestation levels of *R. ferrugineus*. The work consisted of two field choice tests, comparing pyramidal traps with three colours in the first test and comparing the insect captures in pyramidal and buckets traps with the same colour in the second test (fig. 1).

Bucket traps (fig. 2A) were formed by a plastic bucket of 10 l capacity with three oval windows cut equidistantly below the upper rim of the bucket. Inside the trap was placed a funnel to prevent the escape of the weevils. A lid covers the upper part of the receptacle, with three windows like the container holes and a piece of wire to put chemical attractants on (pheromone and kairomone dispensers). Finally, the outer surface of the bucket has a rough texture, to help the insects climb and enter into the trap. Pyramidal traps (fig. 2B) consist of a truncated cone of plastic with a slope of 66% and with a single hole in the bottom, ending in an invagination which acts as a funnel. Inside the truncated cone was placed a bucket with 4 l capacity. A lid with a basket to put inside the chemical attractants covers the upper part of the cone. Finally, the outer surface of the trap have concentric rings of 1 mm relief in order to

that insects enter easily into. Each model of trap contains: the RPW male aggregation pheromone dispenser (Ferrolure+), composed by 4-methyl-5-nonanol and 4-methyl-5-nonanone (9:1) (FALEIRO, 2005); the kairomone dispenser, containing 40 ml of ethyl acetate (EL-SEBAY, 2003); a piece of infested *P. canariensis* petiole, renewed every 4 weeks; and 4 l of water with propylene glycol. The emission capacity of the pheromone and kairomone dispensers is three months. Pheromone-food baited traps were placed above the ground, because in this position traps capture significantly more weevils than traps located at height (OEHLSCHLAGER *et al.*, 1993).

Figure 1: Distribution of the two choice tests in the nursery. Lines delineate the nursery plots. Circles in right area are the four repetitions of the colour test and squares in left area the four repetitions of the shape test.

Distribution des deux essais comparatifs dans la pépinière. Les lignes délimitent la surface de la pépinière. Les cercles dans l'aire de droite correspondent aux quatre répétitions du test de couleur et les carrés dans l'aire de gauche aux quatre répétitions du test de forme.



COLOUR TEST

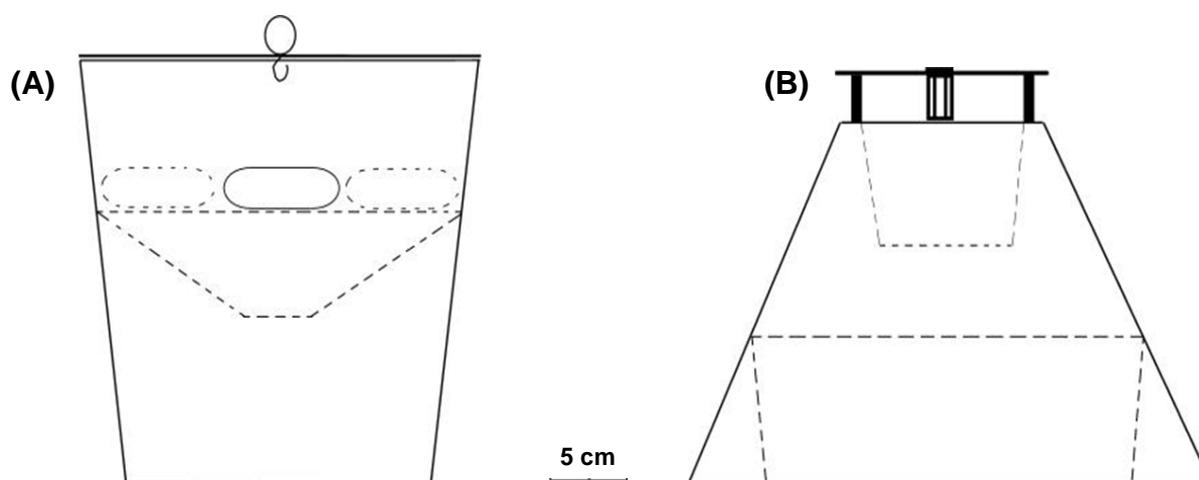
12 pyramidal traps were placed in the field on 6 September, distributed in four repetitions. Each repetition had three traps of black, white and terracotta colour. Adult captures sampling were performed weekly for 15 weeks to determine the most attractive colour to RPW adults.

SHAPE TEST

8 black traps were placed in the field on 27 September of which four are pyramidal and four are bucket traps, distributed in four repetitions. The trap colour were black because in a previous compared colour trap study (ÁVALOS *et al.*, 2010), the black captured significantly more RPW adults than the other colour traps. Adult captures sampling were performed weekly for 12 weeks.

The distance between traps was 1.2 m for each repetition in order to facilitate to the insects the discrimination among different colours. Moreover, trap position within a repetition was rotated clockwise each time a counting was finished, in order to avoid any influence of any trap position in the results.

Figure 2: (A) Bucket and (B) pyramidal trap designs, used for capturing RPW adults. Dessin (A) du piège seau et (B) du piège pyramidal, utilisés pour capturer les charançons adultes.



STATISTICAL ANALYSIS

Data were subjected to a one-way analysis of variance (ANOVA) to test for differences in the percentages of captured insects in traps between the colour and shape tests and in the sex-ratio (number of females : number of males). Means were separated using Fisher's Least Significant Difference (LSD) test with 95% confidence level. Because we analyzed data in percentages and in some of the counts the number of captured insects was very low, in the data analysis, the samples in which the total number of captured RPW were less than 10 adults in all the traps of a repetition (colour test: 3 traps/repetition; shape test: 2 traps/repetition) were not taken into account.

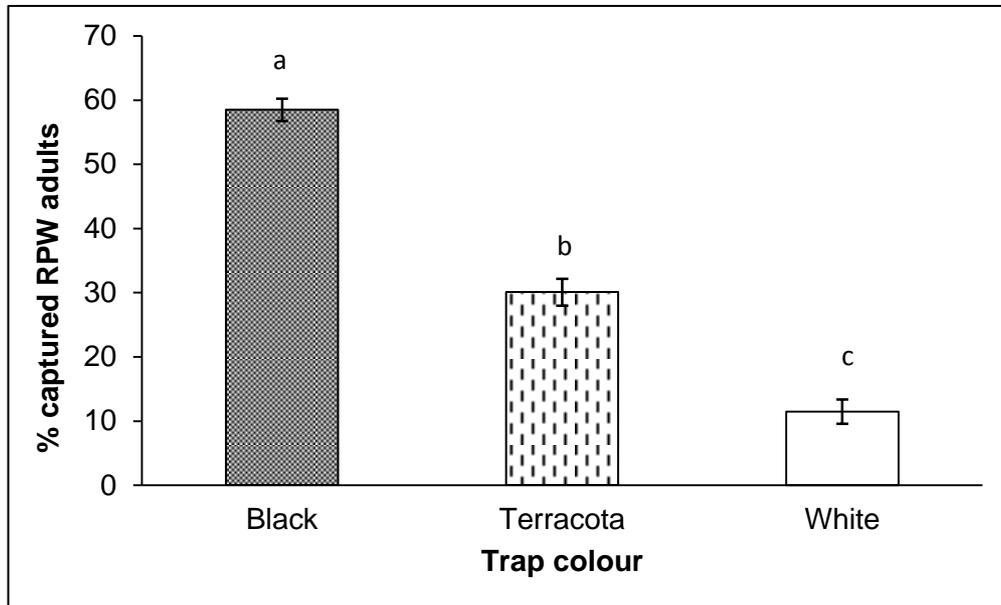
RESULTS

COLOUR TEST

In this test, which compared black, terracotta and white pyramidal traps, the total number of captured weevils was 854 in black traps, 459 in terracotta and 164 in white ones. The mean (\pm SE) of captured adults per sampling and repetition was 18.6 ± 1.6 , 10 ± 1.2 and 3.6 ± 0.5 in black, terracotta and white traps respectively. Black traps captured significantly more RPW adults than the terracotta and white traps ($F = 220.75$; d.f. = 2, 33; $P = 0.0000$) (fig. 3). At the same time, terracotta traps captured significantly more adults than white ones. In percentages, black traps captured a mean (\pm SE) of $58.5 \pm 1.74\%$ RPW adults, about double that of terracotta, with $30.1 \pm 2.08\%$ and five times more than white traps with $11.5 \pm 1.89\%$.

The captured adults sex-ratio, ranged from 1.62 to 1.97, with a sex-ratio mean of 1.82 ± 0.1 females per male, showing no significant differences between tested colours ($F = 0.76$; d.f. = 2, 32; $P = 0.4742$). Of these colours, none of them showed a significant higher sex-ratio of female captures with respect to males.

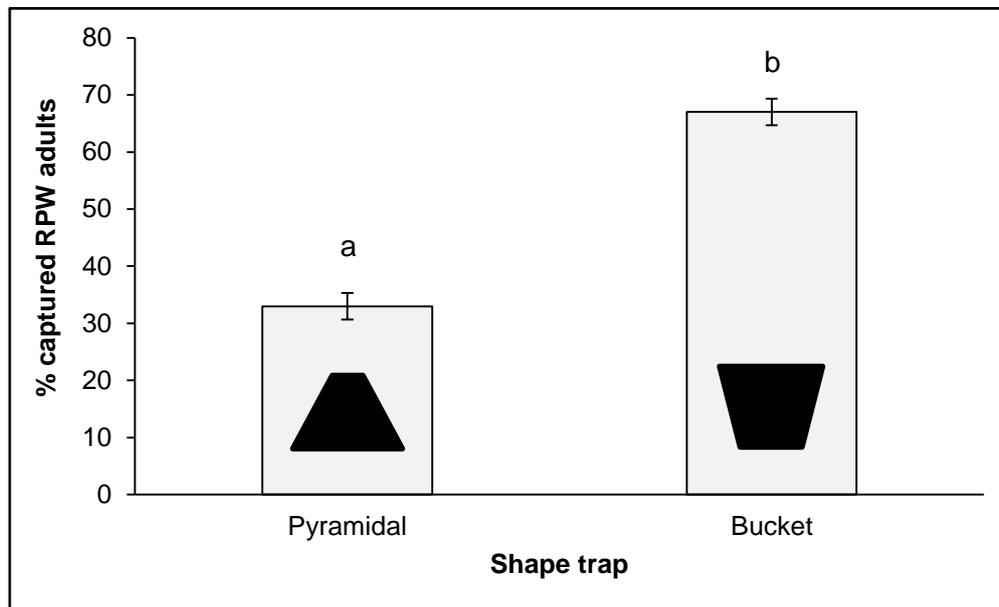
Figure 3: Percentage (mean \pm SE) of *R. ferrugineus* adult catches by trap colour (ANOVA $P < 0.05$; LSD test) (Pourcentages (moyenne \pm SE) de captures d'adultes de *R. ferrugineus* par couleur de piège (ANOVA $P < 0.05$; LSD test)).



SHAPE TEST

In this second test we compared traps with the same colour but with different shapes, analyzing pyramidal and bucket form. In the bucket traps the total number of caught red palm weevil adults was 879 and 487 in pyramidal traps. The mean (\pm SE) of captured adults per sampling and repetition was 23.8 ± 3.6 and 13.2 ± 2 in bucket and pyramidal traps respectively. In percentages, bucket traps caught a mean (\pm SE) of $67 \pm 2.33\%$ of RPW adults, significantly more than pyramidal traps, which captured $33 \pm 2.33\%$ ($F = 106.78$; d.f. = 1, 20; $P = 0.0000$) (fig. 4).

Figure 4: Percentage (mean \pm SE) of *R. ferrugineus* adult catches by trap shape (ANOVA $P < 0.05$; LSD test) (Pourcentages (moyenne \pm SE) de captures d'adultes de *R. ferrugineus* par forme de piège (ANOVA $P < 0.05$; LSD test)).



DISCUSSION

The colour test, carried out in the field, showed that black was the most attractive between of the tested trap colours and also that bucket traps captured more RPW adults than pyramidal traps.

It was found that black traps captured significantly more RPW adults than terracotta and white ones. Few works analyze black colour attraction for RPW adults. HALLET *et al.* (1999) compared captures in black and white traps, obtaining significantly more captures in the first. Moreover, ÁVALOS *et al.* (2010) also compared these two colours, but in addition to red, yellow and blue, confirming that among of these the most and the least attractive are black and white traps respectively. While in this work black traps were the most attractive, terracotta traps also caught significantly more adults than white ones. SANSANO *et al.* (2008) reported that brown captured more adults than white and traps camouflaged with palm fibres. Other studies in which white obtained the least captures of RPW adults are the works conducted by MARTÍNEZ *et al.* (2008) and AL-SAOUD *et al.* (2010). On the other hand, the studies of TAPIA *et al.* (2010), FALEIRO (2005), and ALFARO *et al.* (2011), did not show significant differences between compared colours. In the work of AJLAN & ABDULSALAM (2000) can be drawn no conclusions about the preference for a single colour because were compared traps with different colours in the same trap. Generally it seems that *R. ferrugineus* adults are more attracted to dark colour traps. Moreover, these are the colours that are found in palm tree structures such as the trunk or palm petioles.

In regard to the sex ratio of weevils captured in the colour test, we could not find significant differences between the three tested colour traps. More females were caught in all the tests. Studies conducted by FALEIRO (2005) in which were caught 2 females per male, and by ABDALLAH & AL-KHATRI (2005) with 1.62 females per male, agree with our results.

As the shape test showed, bucket traps captured significantly more RPW adults than the pyramidal model. It was expected that a positive slope in the external trap structure would help the insects to climb and enter into the trap, and that consequently the number of captured RPWs would be higher. ALFARO *et al.* (2011) compared black pyramidal traps with terracotta pyramidal and standard bucket traps, reporting that the first were significantly the most effective in the capture of RPW adults. In the same test two different external aspects were analyzed,

making it unclear whether the results were due to the effect of the colour or the shape. We do not know the colour of the compared commercial trap model, but generally these traps are white, red or yellow, which are not the most attractive colours according to ÁVALOS *et al.* (2010) study. HALLET *et al.* (1993) also tested different modifications to the bucket trap to capture RPW, comparing standard bucket, funnel bucket and inverted bucket traps, obtaining the best results with the standard bucket trap. Moreover, different trap forms were previously developed for other *Rhynchophorus* spp., such as the South American Palm Weevil, *R. Palmarum*. In his work, OEHLISCHLAGER *et al.* (1993) compared different trap models concluding that bucket traps were generally those that exhibit major advantages.

CONCLUSIONS

The present results demonstrated that among black, terracotta and white traps, the first is significantly the most attractant trap colour for *Rhynchophorus ferrugineus* adults in a close range choice situation. Moreover, terracotta traps attracts significantly more adults than white ones. Although it seems that a pyramidal shape help insects to enter the traps, significantly higher percentage of *R. ferrugineus* adults were captured with the bucket form. Therefore, the combined results of our two tests indicate that black bucket traps are the most effective in the capture of RPW adults. A good combination of the external factors of the trap, such as colour and shape, provide a more effective system to monitoring and control, contributing to a better management of this serious pest.

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