

# Effect of Trap Size and Pheromone Capsule Types on the Trapping Efficacy for the Red Palm Weevil (*Rhynchophorus Ferrugineus*)

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**Abstract** – The Red palm weevil (RPW), *Rhynchophorus ferrugineus* (Curculionidae: Coleoptera) is an indigenous species from South East Asia which has recently become one of the most dangerous pests of palms around the globe. Monitoring and mass trapping of weevils with synthetic male aggregation pheromone and food baited traps has been an important component of Integrated Pest Management (IPM) program against RPW. The aim of this study is to evaluate the effect of 2 parameters (trap model and size, and capsule type) on trap effectiveness in catching *Rhynchophorus ferrugineus*. Food-baited pheromone traps were installed in the infested sites of Tunisia. Three different traps were tested (large (10 l) and small 2l) and electrap. Second, we compared four types of aggregation pheromone capsules: M2I classic capsule, M2I new formula, Rhyncho plus (EZ) and ISCA). There was no significant difference between Electrap and the large bucket. However this latter seemed more performing than the small trap. Moreover, our studies provide information for optimizing trap density using black large traps combined with M2I classic capsule of pheromone for mass trapping program. For M2Inew capsule seems to be better at the beginning, after 3 weeks ISCA is better and remains more.

**Keywords** – Rpw, Trap, Size, ISCA, Rhyncho plus and M2I Pheromones, Effectiveness, Mass Trapping.

## I. INTRODUCTION

The red palm weevil, *Rhynchophorus ferrugineus* (RPW) (Olivier) (Coleoptera: Curculionidae) is an economically important pest of palm trees in the different growing area in the world ([1]; [2]; [3]; [4]).

RPW is originally from South Asia where it is a major pest of coconut. In the Mediterranean basin RPW has become a key pest of *P. canariensis* which is extremely sensitive to its attack [5].

By the mid-1980's, multiple introductions of *R. ferrugineus* to the Middle East from Pakistan and India have occurred and the Asian palm weevil is now a serious pest of date palms, in the Arab Gulf States.

The rest of the Mediterranean countries were totally infested by 1994, eventually to report the pest attack in North America in 2009 [6].

The RPW reportedly attacks over 26 species of palm belonging to 16 genera globally in several regions of the world.

The latest report of an RPW invasion occurred in late 2011 in Tunisia where it was found infesting Phoenix canariensis.

Infested palms are hard to detect since the larvae feed on the internal tissues of the palm. Under careful

observation, surveyors may be able to detect infested plants with holes in the crown or trunk. Additionally, distorted or “clipped” fronds may be seen. leaves may droop because of loss of support by bored axils and a collapsed canopy [7]. A very typical sign of infestation is the distorted growing point at the top of the palm. The growth at the top of the canopy can become deformed and offset. This distortion is a very common symptom and is more easily seen than other symptoms of infestation.

As the eggs of RPW are deposited inside concealed places of the stem, larvae hatch and start destructing reaching generally the apical growth area [8].

Life cycle is than wholly sealed within the stem upon emergence of the adults from the cocoon which fly out and infest new palms or remain in the same palm and cause re-infestations at a new site [9].

An integrated pest management (IPM) program has been chosen as the most effective system recently developed in the countries concerned by the infestation.

Regular surveillance is the first necessary step for a swift detection even though palms in the early stages of attack are difficult to detect but can be cured with insecticide (stem injection). Palms in the later stages of attack often host several overlapping generations of the pest with a more severe tissue damage and have to be eradicated [2].

Preventive and curative methods were often based on chemical pesticides, until an extended alternative has been introduced involving the use of natural enemies ([7]; [8]). The male aggregation pheromone of *R. ferrugineus* was identified as 4-methyl-5-nonanol and 4-methyl-5-nonanone by Hallett et al. (1993) and soon commercial formulations were available for monitoring or mass trapping. The pheromone components 4-methyl-5-nonanol and 4-methyl-5-nonanone in the ratio of 9:1 was found to be effective for attracting both male and female adults of RPW [10] Pheromone trapping of adult palm weevils was used to capture and kill the insect to reduce the insect populations in the field ([1]; [11]). The aggregation pheromones have high potential in the management of palm weevils especially the *R. ferrugineus* as it attracts both males and females ([9]; [11]; [12]; [13]). The trapping methods are also advantageous as they are efficient in attracting a much higher percentage of females in comparison to males and this kind of pheromone based system helps in further reducing progenies ([13]; [14]; [15]). Moreover, for the success of IPM it is necessary to know the optimum number of traps for a specific unit area.

Studies showed that more traps per hectare are necessary to capture more adults in little time. Using from 4 to 8

traps/ha enhance the efficacy of monitoring and mass trapping program of rpw in Tunisia [16].

The color of the trap is a key factor in attracting and trapping many insect species [17].

Many studies have examined the trap color preferences of *R. ferrugineus*, ([2]; [10]), although others identified black as the insects' favorite color ([16]; [17]; Al-Saoud, 2013; Vacas et al., 2013; Abdel- Azim et al., 2014; Dhouibi and Ncib, 2016).

The trap design is important: depth of digging must be set so that entry holes, as close as possible to ground level, are easily accessible by weevils.

Used components are pheromones, semiochemicals and food attractants.

The aim of this study is to evaluate the repercussions of three trap volume and different pheromones and types of capsule of pheromone on the efficiency of mass trapping in numerous infected fields in the state of Tunis and its suburban area.

## II. MATERIALS AND METHODS

### Study Sites

In this article we treated 4 experimental fields included within the regions concerned by the trapping campaign. Each site was marked by its population of stems and the density of plantation.

#### 1.1. National Gard of Tunisia (*L'aouina*)

The traps were placed in this site starting on August the 11th 2016 and their survey was carried on until December the 10th 2016. In that period the infestation level was high.

There are 28 palms including 5 infested palms and the infestation by RPW was first reported from this region. In this field tested traps consisted of: 10 l black plastic bucket, with four  $6 \times 4$  cm holes cut below the upper rim (Figure 1). Black traps were used to compare the efficiency of two pheromones: M2I and ISCA (Figure 2).



Fig. 1. Black trap standard



Fig. 2. ISCA capsule (1) and M2I capsule (2)

#### 1.2. Saada Park (*La Marsa*)

This trial was conducted in Saâda Park La Marsa on September the 28<sup>th</sup> 2016. The population was 184 canariensis palm trees among which 22 were infested. We followed *R.ferrugineus* standardizing the trap density to 6 traps/ha. In this site we compared the effectiveness of two

types of pheromone (ISCA and M2I) on 10 l black bucket.

#### 1.3. National Institute of Agronomy of Tunisia

In the residence, the trap density has been standardized to 6 traps/ha. The total number of placed traps was 30 traps. In the following the trapping effects of 2 types of pheromone (ISCA and M2I) were compared.

#### 1.4. *Ipst Rades (Ben Arous)*

This trial was conducted in IPST Ben Arous on September the 16<sup>th</sup> 2016. The population was 184 canariensis palm trees among which 22 were infested.

In this site, the trap density, the trap color and the capsule of pheromone have been standardized to 6 black traps/ha using ISCA capsule.

The main of this essay is to test the efficacy of the trap volume. We placed in total 20 black traps using the ISCA capsule of pheromone.

#### 2. Trap Design, Color and Installation

In the current study, the trap color was the color of the plastic material itself.

The trap color was standardized to black.

Each trap contained one pheromone dispenser and one kairomone capsule that were attached to the lower surface of the trap lid by a wire.

For the bait and the fermentation substances dates and water were used respectively and were regularly changed every 15 days.

The big traps are a 10 L plastic bucket. Trap height was 40 cm, and the diameter of the top and bottom was 18 cm. Each trap had four equidistant circular (5cm width) openings whose lower limits are tangent to the ground surface to allow *R. ferrugineus* entrance (Figure 3).

The small trap or pitfall trap has a smaller size, a middle gap between the two parts of the trap allow the entrance of the pest (Figure 3).



Fig. 3. Large trap (L) and small trap (S)

The other type of trap tested in our trials was electrap. (Fig 4).



Fig. 4. ELECTRAP®

#### 3. Types of Pheromone Tested

Four aggregation pheromone lures were evaluated for

RPW in this article.

*Pheromone 1:* ISCA contains just the insect's aggregation pheromone and must be used with a capsule of Kairomone.

*Pheromone 2:* RhynchoPro classic dispensers contain the insect's pheromone and palm tree volatiles (kairomones) mimicking the odor of damaged palm. This combination of pheromone and synergists is highly attractive to both male and female weevils. This product is under the trade mark M2i

*Pheromone 3:* RhynchoPlus (Fig. 5) (EZ) is a gel formulation of the pheromone of *R. ferrugineus* (Mixture of ferrugineone and ferruginol). The content of the dispenser dissipates slowly and at a constant rate ensuring optimum evaporation over a period of 90 days.

*Pheromone 4 :* a blend of Ethanol/Ethyl Acetate (3/1) to mimic the natural melasse which is the kairomone? Composition and the aggregation pheromone feruginol The product is under trade mark M2i. This product is characterized by extra amount of kairomones our trials this composition is called M2in (new formulation).



Fig. 5. Rhyngo Plus (EZ) capsule of pheromone

#### 4. Trap Density

In order to maximize the weevils capture, in each site 6 traps/ha were installed. The distance from a trap to a palm is between 1 and 2 m.

#### 5. Weekly Servicing and Data Collection

All the traps were examined every week and RPW adults captured in each trap were recorded in both the experiments. After removing dead insects all traps were replenished with fresh date fruits/stem pieces, water and detergent. The Pheromone sachets were replaced with new ones in all traps after six weeks to eliminate any differences in available pheromone.

### III. RESULTS

The results show that the RPW was active throughout the year. Nevertheless, at the start of the experiment (09/15/2016) we recorded a low number of captures (between 0 and 1) which then rose (between 0 and 11) at the end of the survey date. Furthermore, Figures (6, 7 and 8) reveal that trap volume, and type of pheromone influenced weevil captures in food baited RPW pheromone traps.

#### 1. Effect of Trap Size on the Trapping Number of RPW

##### 1.1. IPST Rades (Ben Arous)

For all trap sizes combined and for all sampling dates, the mean and variance of the number of adults per trap were 1.03 and 1.80, respectively. The variance / mean ratio of the number of adults per trap is thus 1.73, indicating a possible over dispersion at the distribution level. The number of adults per trap varied from 0 to 7. Additionally, only 52.22% of installed traps exhibited at least one adult trapped. In these traps, the mean number of adults trapped is  $1.98 \pm 1.25$  ( $\pm$  SD).

FIG. 6 represents the histogram of the distribution of the number of adults trapped for the two types of trap, all sampling dates combined, with the number of adults trapped on the x-axis and the ordinates on the ordinate.

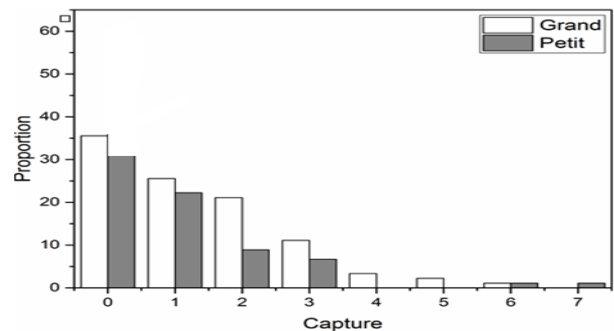


Fig. 6. Distributions observed by the number of adults trapped and the size of the trap used.

The frequency of traps with no trapped adults is significantly associated with trap size ( $Pr > \text{Chi-2} = 0.0012$ ). The frequency of traps with no adult trapped is greater in small traps (60% vs. 35.56% for large traps,  $OR = 2.719$ , 95% CI [1.487 - 4.971]).

The over dispersion of the distribution of the number of trapped adults is significant, since the Zero-Inflated Negative Binomial (ZINB) negative Binomial model is preferred over that of the negative Binomial model (Negative Binomial, (NB) and those with a fish component (Poisson or Poisson Model, denoted P, and Zero-Inflated Poisson, ZIP). Over dispersion may be due in part to excess zeros.

The graphical representation confirms the results of the statistical tests, with a good adequacy observed for the ZINB model (Figure 2).

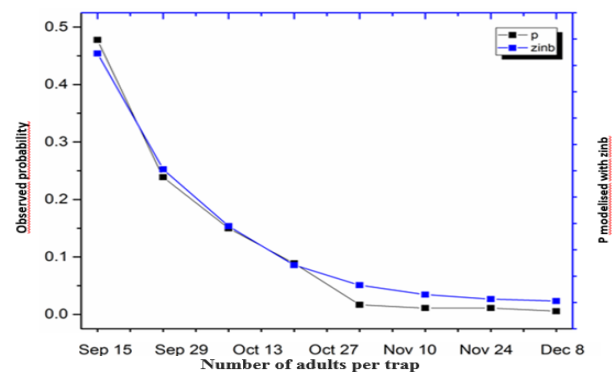


Fig. 7. Distributions observed and predicted by the ZINB model of probability according to the number of adults trapped per trap.

According to the ZINB model (generating two separate models then combined: Binomial negative and logistic), it appears that the number of adults trapped (adjusted using the negative Binomial model) is influenced only by the measurement date ( $Pr > Chi-2 = 0.0005$ ); It did not depend on the size of the trap ( $Pr-Chi-2 = 0.5828$ ). The adjusted average number remained relatively low with a slight increase in October (Figure 7).

Concerning the logistic part of the ZINB model (modeling the extra zeros), the trap size is significantly related ( $Pr > Chi-2 = 0.0138$ ) to the probability of belonging to the "extra-zeros" group. According to the parameters of the adjusted model, and all other things being equal, the odds of being an extra-zero is  $\exp(-0.4583) = 0.63$  (i.e. a proportion of 0.39) when the trap is small and  $\exp(-23, 174) = 0.00$  when the trap is large.

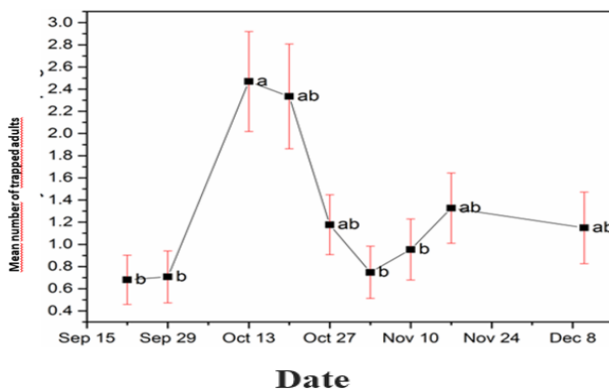


Fig. 8. The mean number of adults trapped estimated by the ZINB model according to the measurement date.

In the end, the model that best adjusts the number of trapped adults is the ZINB model, certainly because of the "extra zeros" (i.e., the absence of trapped individuals). According to the ZINB model, small traps exhibited a significant proportion of extra zeros. However, the size of the traps should be tested during the full activated period of the insect in order to verify the effectiveness of the large traps in the trapping of the insects studied.

### 1.2. Plot Ben Abdallah (Ariana)

For all trap types combined and for all sampling dates, the mean of the number of adults per trap was  $0.87 \pm 0.1$  ( $\pm$  SD). The numbers of adults per trap varied from 0 to 2.

The distribution of the number of adults trapped for the two types of trap. (Fig.9).

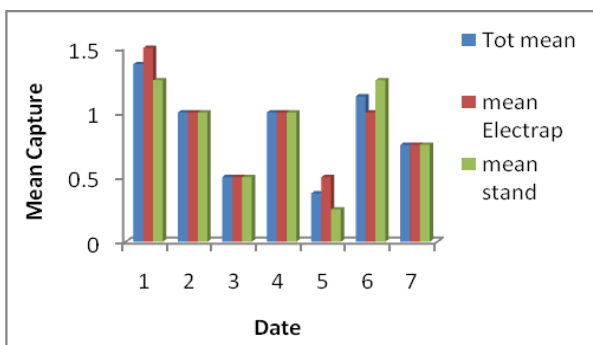


Fig. 9. Distributions observed by the mean capture of adults trapped and the types of the trap used.

There were no significant differences between trap types in the number of captured weevils  $Pr(T > t) = 0.5768$ . During the trapping period, mean of captures of *R. ferrugineus* recorded in standard traps is  $0.8965517 \pm 0.1433658$  ( $\pm$  SD) adults/trap from all dates, which was not significantly different from ELECTRAP traps (mean captures =  $0.8565517 \pm 0.1428571$  ( $\pm$  SD) adults/trap) for all the examination dates (Table 1).

The analysis of the catch averages confirms the following results as shown in this table.

Table 1. Two-sample t test with equal variances (Mean capture)

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]
ELECTRA	28	.8571429	.1428571	.7559289	.5640242 1.150262
Standard	29	.8965517	.1433658	.7720486	.6028801 1.190223
combined	57	.877193	.1003446	.7575849	.6761787 1.078207
diff		-.0394089	.2024668		-.4451614 .3663437

diff = mean(ELECTRA) - mean(Standard)  $t = -0.1946$   
 $H_0: \text{diff} = 0$  degrees of freedom = 55  
 $H_a: \text{diff} < 0$   $H_a: \text{diff} \neq 0$   $H_a: \text{diff} > 0$   
 $Pr(T < t) = 0.4232$   $Pr(|T| > |t|) = 0.8464$   $Pr(T > t) = 0.5768$

### 1.1. Plot Julien (Ariana)

For all trap types combined and for all sampling dates, the mean of the number of adults per trap was  $1.571429 \pm 0.1573323$  ( $\pm$  SD)... The number of adults per trap varied from 0 to 6. The distribution of adults captured for the two types of trap is presents in Fig.10

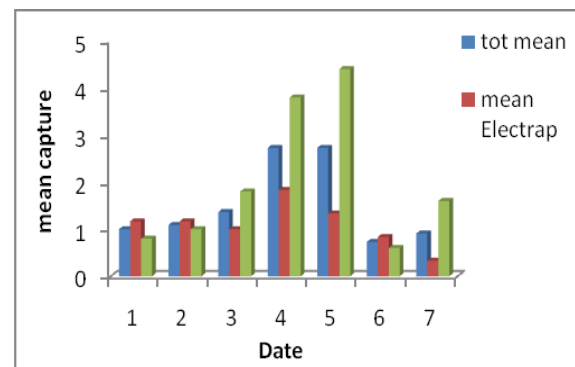


Fig. 10. Distributions observed by the mean capture of adults trapped and the types of the trap used.

There were no significant differences between trap types in the number of captured weevils. During the trapping period, mean of captures of *R. ferrugineus* recorded in standard traps is  $1.47619 \pm 0.2214882$  ( $\pm$  SD) adults/trap from all dates, which was not significantly different from ELECTRAP traps (mean captures =  $1.685714 \pm 0.2236873$  ( $\pm$  SD) adults/trap) for all the examination dates (Table 2).

The analysis of the catch averages confirms the following results as shown in this table.

Table 2. Two-sample t test with equal variances (mean capture)

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]
Electrap	35	1.685714	.2236873	1.323352	1.231127 2.140302
Standard	42	1.47619	.2214882	1.435408	1.028886 1.923495
combined	77	1.571429	.1573323	1.380585	1.258074 1.884783
diff		.2095238	.317151		-.4222733 .8413209

diff = mean(Electrap) - mean(Standard)  $t = 0.6606$   
 $H_0: \text{diff} = 0$  degrees of freedom = 75  
 $H_a: \text{diff} < 0$   $H_a: \text{diff} \neq 0$   $H_a: \text{diff} > 0$   
 $\text{Pr}(T < t) = 0.7446$   $\text{Pr}(|T| > |t|) = 0.5109$   $\text{Pr}(T > t) = 0.2554$

## 2. Effect of Pheromone Type on the Captures of Weevils.

For all pheromone types and for all measurement dates, the mean and the variance of the number of adults per trap were 0.83 and 1.24, respectively. The variance / average ratio of the number of adults per trap is thus 1.50, hence a possible possibility of over dispersion at the distribution level. The number of adults per trap was between 0 and 10. 54.44% of the traps installed showed at least one adult trapped. In these traps, the mean number of adults trapped is  $1.52 \pm 1.22$  ( $\pm$  SD). Fig. 3 shows the histogram of the distribution of the number of adults trapped for the two types of trap, all sampling dates combined, with the number of adults trapped on the abscissa and the ordinates on the ordinate.

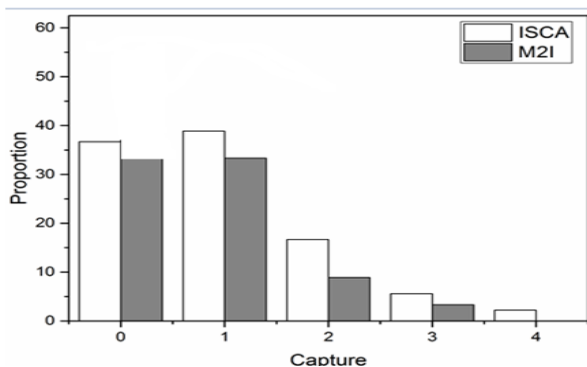


Fig.11. Distributions observed by number of adults trapped and type of pheromone used.

The frequency of traps with no trapped adults is significantly associated with the type of pheromone ( $\text{Pr}(\text{Chi-2} = 0.0173)$ ). The frequency of traps without any adult trapped is lower using the ISCA hormone (37% vs. 54% for the M2I pheromone,  $\text{OR} = 0.484$ , 95% CI [0.267-0.880]). The over dispersion of the trapped adult distribution was not significant, but the Binomial negative (NB) model was preferred over that of the Poisson Model (P). According to the NB model, it appears that the number of adults trapped is influenced by both the measurement date ( $\text{Pr} > \text{Chi-2} = 0.0167$ ) and mainly by the type of pheromone ( $\text{Pr} > \text{Chi-2} = 0.0044$ ); the interaction between these two factors is not significant ( $\text{Pr}$

$> \text{Chi-2} = 0.1156$ ). The mean number of trapped adults was significantly higher using the ISCA pheromone ( $0.9892 \pm 0.1136$ ) than the M2I pheromone ( $0.5812 \pm 0.08378$ ). A significant increase in the number of adults trapped was observed around mid-October (Figure 12).

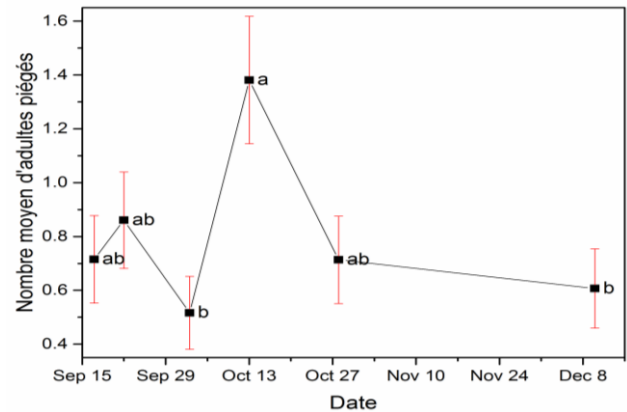


Fig. 12. The mean number of adults trapped estimated by the ZNB model by date of measurement.

In the end, the type of pheromone has a significant effect on the number of adults caught per trap. This number was adjusted using the negative binomial model.

The pheromone type has been proven to have an effect on the number of captures ( $\text{pr} > \chi^2 = 0.0023$ ). Also, the interaction between pheromone type and capture date was significant which means that the effect of pheromone type depends on the date of capture.

### 1.1. Pastor Institute and Soukra Park

For all pheromone types and for all measurement dates, the mean of the number of adults per trap was  $1.434343 \pm 0.1586908$  ( $\pm$  SD). The numbers of adults per trap varied from 0 to 6.

Fig. 7 shows the histogram of the distribution of the number of adults trapped for the three types of pheromones.

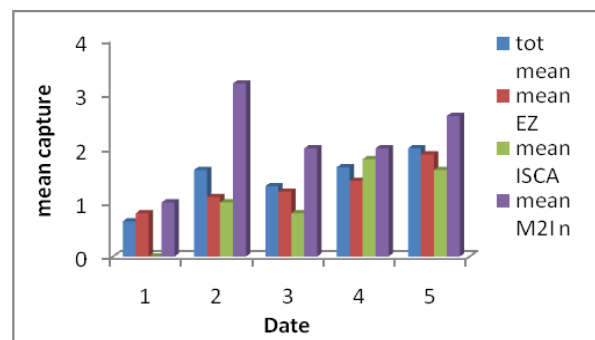


Fig.13. Distributions observed by the mean capture of adults trapped and the type of pheromone used.

The pheromone type has been proven to have an effect on the number of captures ( $\text{Pr}(T > t) = 0.9599$ ).

As described in figure 13, the number of captures in this Site was higher when (M2In) type pheromone was used compared to the ISCA and EZ type pheromones.

The conclusion to be held from all dates support the significant higher capture efficiency for traps with M2In

Type pheromone ( $2.52 \pm 0.356$  adults/ trap/ week) against the traps equipped with ISCA type pheromone ( $1.6 \pm 0.36$ ) (Tab 3) and  $1.06 \pm 0.172$  0 (Tab 4).

Table 3. Two-sample t test with equal variances (Mean capture)

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
ISCA	25	1.6	.3605551	1.802776	.8558508	2.344149
m2in	25	2.52	.3564641	1.782321	1.784294	3.255706
combined	50	2.06	.2593713	1.834032	1.538774	2.581226
diff		-.92	.5070174		-1.939427	-.0994269

diff = mean(ISCA) - mean(m2in)  $t = -1.8145$

Ho: diff = 0 degrees of freedom = 48

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0

$\Pr(T < t) = 0.0379$   $\Pr(|T| > |t|) = 0.0758$   $\Pr(T > t) = 0.9621$

Table 4. Two-sample t test with equal variances (mean capture)

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
EZ	50	1.02	.1725913	1.220405	.6731648	1.366835
ISCA	25	1.68	.3988316	1.994158	.856852	2.503148
combined	75	1.24	.1779159	1.540797	.8854949	1.594505
diff		-.66	.3720583		-1.401511	.0815112

diff = mean(EZ) - mean(ISCA)  $t = -1.7739$

Ho: diff = 0 degrees of freedom = 73

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0

$\Pr(T < t) = 0.0401$   $\Pr(|T| > |t|) = 0.0802$   $\Pr(T > t) = 0.9599$

In the end, the type of pheromone has a significant effect on the number of adults caught per trap.

The pheromone type has been proven to have an effect on the number of captures ( $\Pr > \Pr(T > t) = 0.9599$ ).

### 1.2. National Institute of Agronomy of Tunisia

For all pheromone types and for all measurement dates, the mean of the number of adults per trap was  $2.42 \pm 0.2857491$  ( $\pm$  SD). The numbers of adults per trap varied from 0 to 8.

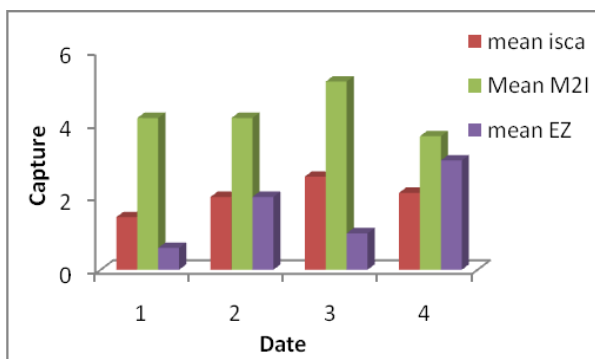


Fig. 14. the distribution of the number of adults trapped for the three types of pheromones.

The pheromone type has been proven to have an effect on the number of captures ( $\Pr(T > t) = 0.942$ ).

As described in figure 8, the number of captures in this site was higher when (M2In) type pheromone was used compared to the ISCA and EZ type pheromones?

The conclusion to be held from all dates support the significant higher capture efficiency for traps with M2In type pheromone ( $4.29 \pm 0.3$  adults/ trap/ week) against the traps equipped with ISCA type pheromone ( $3 \pm 0.62$ ) (Tab 5) and  $2 \pm 0.35$  (Tab 6).

Table 5. Two-sample t test with equal variances (mean capture)

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
ISCA	36	3	.6261497	3.756898	1.728848	4.271152
M2I	24	4.291667	.3038352	1.488482	3.663136	4.920198
combined	60	3.516667	.4009112	3.105444	2.714445	4.318888
diff		-1.291667	.8077676		-2.908589	.3252558

diff = mean(ISCA) - mean(M2I)  $t = -1.5991$

Ho: diff = 0 degrees of freedom = 58

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0

$\Pr(T < t) = 0.0576$   $\Pr(|T| > |t|) = 0.115$   $\Pr(T > t) = 0.942$

Table 6. Two-sample t test with equal variances (mean capture)

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
EZ	40	2	.3526457	2.230327	1.286707	2.713293
ISCA	36	3	.6261497	3.756898	1.728848	4.271152
combined	76	2.473684	.352173	3.070173	1.77212	3.175249
diff		-1	.7004932		-2.395763	.3957631

diff = mean(EZ) - mean(ISCA)  $t = -1.4276$

Ho: diff = 0 degrees of freedom = 74

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0

$\Pr(T < t) = 0.0788$   $\Pr(|T| > |t|) = 0.1576$   $\Pr(T > t) = 0.9212$

In the end, the type of pheromone has a significant effect on the number of adults caught per trap.

The pheromone type has been proven to have an effect on the number of captures ( $\Pr(T > t) = 0.942$ ).

## IV. DISCUSSION

Abraham et al. (1998) described various methods under IPM for the management of RPW including surveillance and trapping of weevils with pheromone lures. Though mass trapping of RPW was an important component of IPM, the trapping density was not followed systematically and was based on the ease of servicing regularly [13].

The tests both with the two types of pheromone capsule (M2I) and (ISCA) showed evidence of aggregation pheromone attraction in *R. ferrugineus*.

The use of pheromones in monitoring and controlling RPW populations has become an important tool for managing this pest [19]. The factors that influence the ability of pheromone-food baited traps to monitor populations of red palm weevil include the following: dose, ratio, release rate of the pheromone blend from the lure [20], longevity of the lure over the trapping period [21] and lure type [19].

Studies also tested different modifications to the bucket trap to capture RPW, comparing standard bucket, funnel bucket and inverted electrap, obtaining the best results with the standard bucket trap [10].

In conclusion, the present study shows the importance of the pheromone type used to capture insects. Black traps with ISCA capsule of pheromone substantially increase insect captures. The upper temperature in black traps is not the only cause of its higher captures. It is also considered that the visual attraction of *R. ferrugineus* traps could be improved by the use of a color with a spectral reflectance as close as possible to the host structures infested by the insects. However, the size of the traps should be tested during the full activated period of the insect in order to verify the effectiveness of the large traps in the trapping of the insects studied. The results obtained in this work could improve the monitoring and mass trapping of *R. ferrugineus* populations [11].

## V. CONCLUSION

Pheromone baited traps have been successfully used to control rpw in several countries including Tunisia. Our studies comparing the effect of trap size and type, when it comes to trap color a major role was highlighted in the effectiveness of weevils trapping.

Present results demonstrated that large traps were more effective than small ones for the experimental site. The present study shows the importance of the pheromone type used to capture insects. Black standard or Electrap traps with M2In capsule of pheromone substantially increase insect captures. The upper temperature in black traps is not the only cause of its higher captures. It is also considered that the visual attraction of *R. ferrugineus* traps could be improved by the use of a colour with a spectral reflectance as close as possible to the host structures infested by the insects. The results obtained in this work could improve the monitoring and mass trapping of *R. ferrugineus* populations.

During the trapping period, the maximum number of rpw captured with traps using ISCA capsule as pheromone was significantly higher than M2I classic Capsule. However compared to M2In (new formulation, it was revealed that using M2In capsule as pheromone was significantly higher than ISCA or Rhyncho plus (EZ) Capsule. But ISCA capsule remains longer than M2In capsule

Standard traps and ELECTRAP traps have the same effectiveness for the experimental sites. During the

trapping period, the mean number of rpw captured with traps

Based on the results presented above, we propose that using 4 to 8 black traps/ha instead of the commonly used large black traps along with ISCA capsules would significantly enhance the efficacy of monitoring and mass trapping program of rpw in Tunisia.

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