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# Nanotechnology Approaches as A Control to The Different Stages of the Red Palm Weevil, *Rhynchophorus ferrugineus* (Olivier) at $LC_{50}$ and $LC_{90}$

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*Rhynchophorus ferrugineus*, nanoparticles, nanotechnology, red palm weevil ZnO-$TiO_2$, CdS.

**ABSTRACT**

Palm trees are of the most important trees in the world. The most dangerous organism to threaten palm trees is the red palm weevil insect *Rhynchophorus ferrugineus* (Olivier) (Curculiondiae: Coleoptera). This study tested three nanoparticles (ZnO, TiO and CdS) against the red palm weevil under laboratory conditions, taking into account that using nanoparticle materials are cheap, available and low toxicity. Different concentrations of each substance were prepared separately including 125ppm, 250ppm, 500ppm and 1000ppm and then followed by feeding adults and larvae on these compounds. Eggs and pupae were exposed to different concentrations prepared from the current examined Nanoparticles. $LC_{50}$, $LC_{90}$ and rate potency of each Nanoparticles (ZnO-$TiO_2$ and CdS) were calculated on all red palm weevil stages. Results showed that the $LC_{50}$ values of the nanoparticles ZnO, $TiO_2$ and CdS on eggs were 78.551, 84.47 and 290.668ppm respectively, however, $LC_{90}$ values were 938.735, 740.955 and 838.378 ppm respectively. Meantime, rates potency were 98.906%, 92.993% and 27.024%, respectively. On the other hand, $LC_{50}$ values of the nanoparticles ZnO, $TiO_2$ and CdS on larvae were 114.88, 367.409 and 868.526 ppm respectively while $LC_{90}$ values were 2526.123, 2542.767 and 4651.173 ppm respectively. In addition, rates potency were 55.435%, 31.268% and 13.227%, respectively. In relation to $LC_{50}$ values of the mentioned nanoparticles on pupae, they were 78.522, 190.349 and 355.874 ppm, respectively. Regarding $LC_{90}$ values, they were 1138.585, 874.974 and 1138.85 ppm respectively. Moreover, rates potency was 68.564%, 41.252% and 22.065%, respectively. On the other hand, $LC_{50}$ values to nanoparticles (ZnO, $TiO_2$ and CdS) on adults were132.115, 207.355 and 290.374 ppm respectively while $LC_{90}$ values were 1412.72, 3013.647 and 2715.978 ppm and to ZnO, $TiO_2$ and CdS were 90.786%, 63.714% and 45.498% respectively. Therefore, it is concluded that the effect of ZnO against the adult stage of red palm weevil is stronger than $TiO_2$ while came CdS in the last rank.

## INTRODUCTION

The red palm weevil (RPW), *Rhynchophorus ferrugineus* (Curculionidae: Coleoptera), has been described as a major pest of coconut and date palm throughout Indian

native habitat (Lefroy, 1906; Brand, 1917 and Buxton, 1920). The red palm weevil has spread to become the endangering species of coconut and date palms in the south and southeastern Asia (Wattanapongsiri, 1966).

The red palm weevil has been reported as a pest in other parts of the world such as Malaysia and the Philippines (Flach, 1983). It has become widely spread to all Persian Gulf States, including Bahrain, Oman, Saudi Arabia, and Iran and then crossed the Red Sea to spread in Egypt (Saleh, 1992 and Cox, 1993). The date palm is considered the most familiar crop in arid areas of the Middle East and in North Africa people have depended on dates as one of the essential kinds of food for a long 5000 years (Jones, 1995).

In Saudi Arabia, palm tree cultivation is one of the most important agricultural activities. Saudi Arabia produces 570.000 tons of dates worth 203 million US$, which exports valued at over 30 million US$ (Anon, 1998).

According to (Abdel-Megeed et al., 2004), Arab countries cultivate 78.3% of the total world date palm trees which yield 75% of the date production. So, the red palm weevil causes a lot of losses that have been estimated in the Arabian Peninsula 30% of the global data production, the damage cost estimated at range from 5.18 to 25.92 million US dollars (El-Sabea *et al.,* 2009).

Concerning another place, the effect of the red palm weevil spread, in California fields (USA) the damage estimated there 70 million US dollars on the ornamental palm (Nisson *et al.,* 2011).

## MATERIALS AND METHODS

Different stages of red palm weevil (*Rhynchophorus ferrugineus*) (adults- larvae-cocoons) were collected from infested date palm trees. Save in a glass basin with a wire cover under room temperature. Different concentration of Nanoparticles CdS, ZnO and $TiO_2$(1000ppm, 500ppm, 250ppm and 125ppm). Four replicates per concentration and one standard without treatment. Glasses jars, plastic cans, Sugarcane, filter paper and dropper.

The sugarcane was put in nanoparticles (ZnO, CdS and $TiO_2$)1000 ppm, 500 ppm, 250 ppm and 125 ppm separately for 15 minutes, and prepared four replicates per concentration added to one replicate standard without treatment.

Five insects (adults and larvae) separately were put on each replicate. Then they were fed on sugarcane which was treated with nanoparticles), and recorded the mortality after five days.

The filter paper was treated with different concentrations (1000 ppm, 500 ppm, 250 ppm and 125 ppm) of nanoparticles ZnO, CdS and $TiO_2$ separately. Then 5 eggs were put on filter paper which was treated with different concentrations of nanoparticles ZnO, CdS and $TiO_2$ separately (four replicates per concentration plus one replicate standard without treatment). The mortality was recorded after five days.

Five pupae were put in plastic jars with perforated covers and then treated with different concentrations of nanoparticles types, each one separately, (four replicates per concentration plus one replicate standard without treatment), and the mortality was recorded after five days.

The mortality of all stages of the red palm weevil was recorded after five days, and then measured $LC_{50}$, $LC_{90}$ and toxicity of Nanoparticles (CdS, ZnO and $TiO_2$) were calculated against the red palm weevil stages by Line Detox Cation Program (LdP) then the results were tabled.

## RESULTS AND DISCUSSION

The effects of nanoparticles (ZnO, TiO2 and CdS) against red palm weevil stages were taken after 5 days of treatment with nanoparticles and the results were as follows:

Table (1), and graphically illustrated as toxicity line in Figure (1) indicate the effects of 3 tested nanoparticles (ZnO, $TiO_2$ and CdS) against the egg stage of red palm weevil (*Rhynchophorus ferrugineus*).

The date is indicated to the $LC_{50}$ values to nanoparticles (ZnO, $TiO_2$ and CdS) on eggs were 78.551, 84.47 and 290.668ppm respectively, while $LC_{90}$ values were 938.735, 740.955 and 838.378 ppm respectively and rates potency were 98.906, 92.993 and 27.024, and the slops (b) of (ZnO, $TiO_2$ and CdS) were 1.19, 1.359 and 2.786 respectively.

The rate potency to ZnO, $TiO_2$ and CdS were 98.906%, 92.993% and 27.024% respectively. These results show that the effect of ZnO against the egg stage of red palm weevil is greater than one while $TiO_2$ came in second place and CdS came in the last rank

**Table 1:** LC values of tested Nanoparticles (ZnO, $TiO_2$ and CdS) against egg stage of **the** red palm weevil.

| Nanoparticles | $LC_{50}$ ppm | $LC_{90}$ ppm | Slope (b) | Rate potency |
|---|---|---|---|---|
| **ZnO** | 78.551 | 938.735 | 1.19 | 98.906 |
| **$TiO_2$** | 84.47 | 740.955 | 1.359 | 92.993 |
| **CdS** | 290.668 | 838.378 | 2.786 | 27.024 |

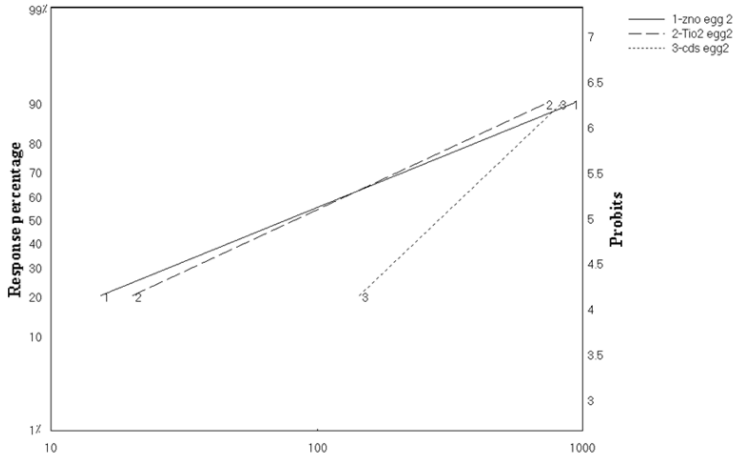


**Fig. (1):** Toxicity lines of tested Nanoparticles against egg stage of the red palm weevil**.**

Data in Table (2) and Figures (2, 3, 4 and 5) indicates the effect of treated larvae of the red palm weevil by three tested nanoparticles (ZnO, $TiO_2$ and CdS).Zinc Oxide (ZnO) proved to be the most effective compound followed by Titanium Dioxide ($TiO_2$) and Cadmium Sulphide (CdS), respectively. $LC_{50}$ and $LC_{90}$ values of ZnO were 114.88 ppm and 2526.123 ppm, respectively. The rate potency of zinc oxide was 55.435% against the larva stage of the red palm weevil.

**Table 2:** LC values of tested Nanoparticles (ZnO, $TiO_2$ and CdS) against larva stage of the red palm weevil.

| Nanoparticles | $LC_{50}$ppm | $LC_{90}$ppm | Slope (b) | Rate potency |
|---|---|---|---|---|
| **ZnO** | 114.88 | 2526.123 | 0.955 | 55.435 |
| **$TiO_2$** | 367.409 | 2542.767 | 1.525 | 31.268 |
| **CdS** | 868.526 | 4651.173 | 1.759 | 13.227 |

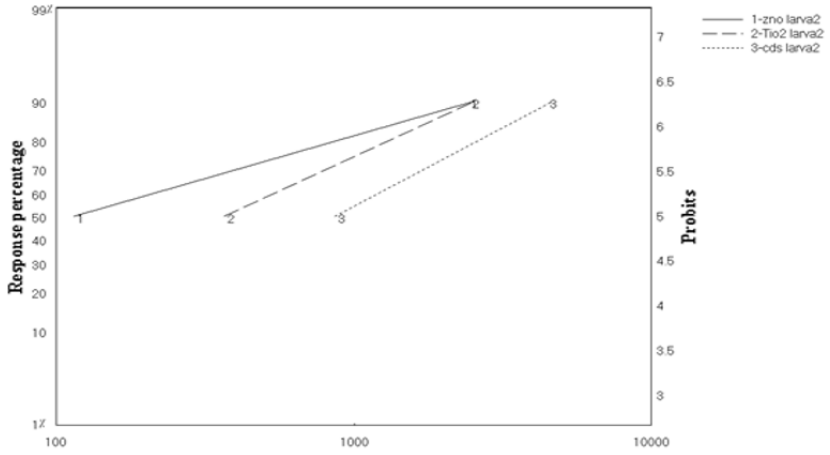


**Fig. (2):** Toxicity lines of tested Nanoparticles against larva stage of the red palm weevil.

**Fig. 3:** Effect of ZnO on larvae stage of RPW, (Drawing Scale of 1 : 2. 59).

**Fig. 4:** Effect of TiO2 on larvae stage of RPW. (Drawing Scale of 1 : 3. 21).

**Fig. (5):** Effect of CdS on larvae stage of RPW,( Drawing scale 1: 3.23)

The effect of treated pupae of the red palm weevil by three tested nanoparticles (ZnO, $TiO_2$ and CdS) was shown by data of Table (3) and Figures (6, 7, 8 and 9). Zinc Oxide (ZnO) proved to be the most effective compound followed by Titanium Dioxide ($TiO_2$) and Cadmium Sulphide (CdS), respectively. $LC_{50}$ and $LC_{90}$ values of ZnO were 78.522 ppm and 1138.585 ppm, respectively. The rate potency of zinc oxide was 68.564% against the pupa stage of the red palm weevil.

**Table 3:** LC values of tested Nanoparticles (ZnO, $TiO_2$ and CdS) against pupa stage of the red palm weevil.

| **Nanoparticles** | **$LC_{50}$ppm** | **$LC_{90}$ppm** | **Slope (b)** | **Rate potency** |
|---|---|---|---|---|
| **ZnO** | 78.522 | 1138.585 | 1.104 | 68.564 |
| **$TiO_2$** | 190.349 | 874.974 | 1.935 | 41.252 |
| **CdS** | 355.874 | 1138.85 | 2.537 | 22.065 |

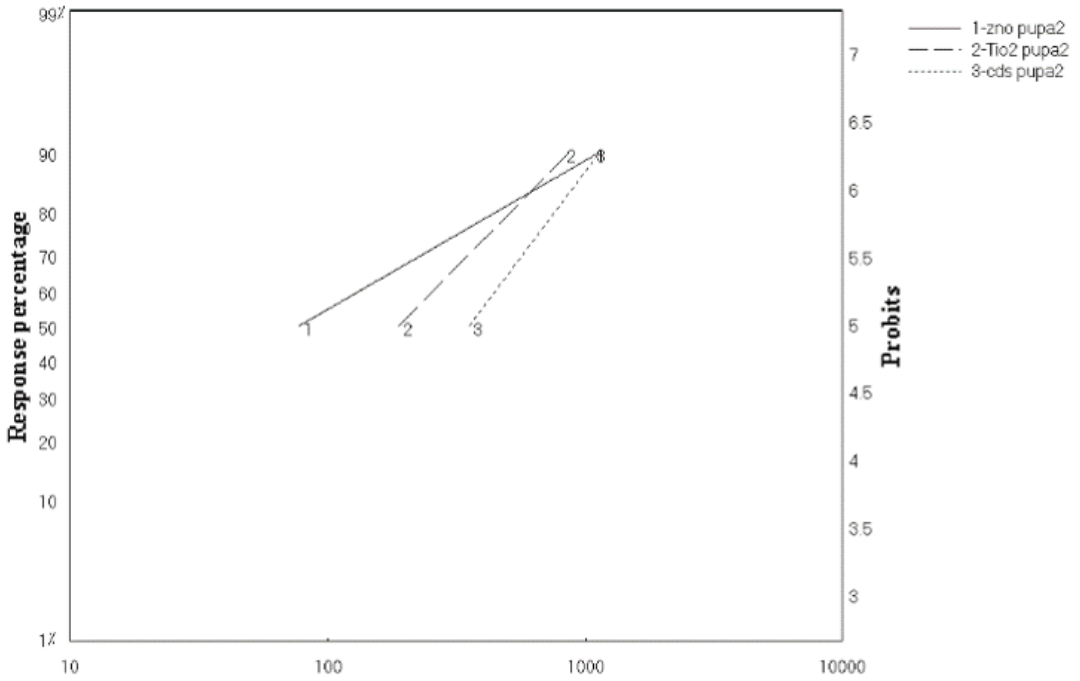


**Fig. (6):** Toxicity lines of tested Nanoparticles against pupa stage of the red palm weevil.

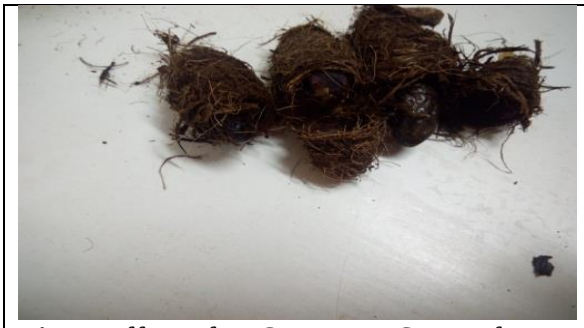

**Fig.7:** Effect of ZnO on pupa Stage of RPW (Drawing Scale.. 1 : 2.36).

**Fig.** 8: Effect of $TiO_2$ on pupa stage of RPW **(**Drawing Scale.. 1 : 1.48)

**Fig. (9):** Effect of CdS on pupa stage of RPW. (Drawing Scale, 1: 1.33).

Data in Table (4) and Figures (10, 11, 12 and 13) indicate the effect of treated adults of the red palm weevil by three tested nanoparticles (ZnO, $TiO_2$ and CdS)**.**

Zinc Oxide (ZnO) proved to be the most effective compound followed by Titanium Dioxide ($TiO_2$) and Cadmium Sulphide (CdS), respectively. $LC_{50}$ and $LC_{90}$ values of ZnO

were 132.115 ppm and 1412.72 ppm, respectively. The rate potency of zinc oxide was 90.786% against the adult stage of the red palm weevil.

**Table 4:** LC values of tested Nanoparticles (ZnO, $TiO_2$ and CdS) against adult stage of **of** the red palm weevil.

| Nanoparticles | $LC_{50}$ppm | $LC_{90}$ppm | Slope (b) | Rate potency |
|---|---|---|---|---|
| **ZnO** | 132.115 | 1412.72 | 1.245 | 90.786 |
| **$TiO_2$** | 207.355 | 3013.647 | 1.103 | 63.714 |
| **CdS** | 290.374 | 2715.978 | 1.32 | 45.498 |

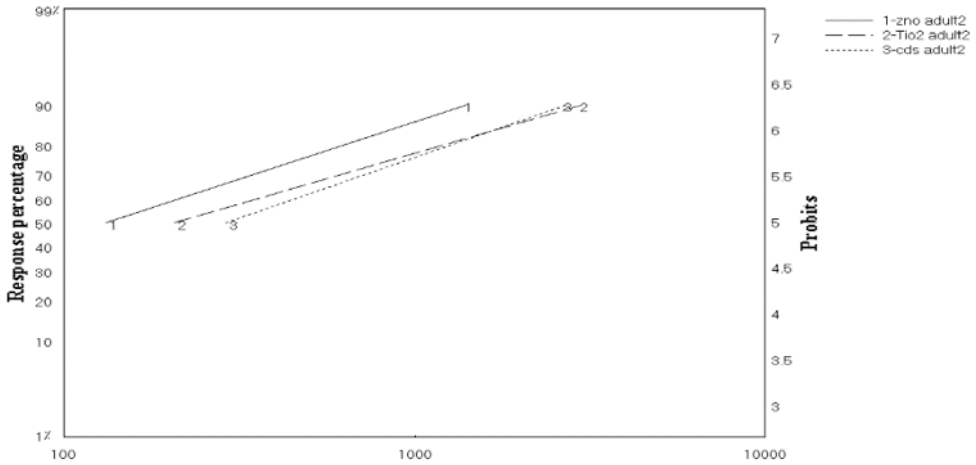


**Fig. (10):** Toxicity lines of tested Nanoparticles against adult stage of **the red palm weevil**.

**Fig. (11):** Effect of ZnO on adult Stage of RPW. (Drawing Scale, 1: 1.77).

**Fig. (12):** Effect of TiO2 on the adult stage of RPW. (Drawing Scale, 1: 2.80).

**Fig. (13):** Effect of CdS on the adult stage of RPW. (Drawing Scale, 1: 2.04).

Figure (14) explained the rates of potency and effect of ZnO, $TiO_2$ and CdS on all stages to the red palm weevil. Zinc Oxide (ZnO) is more effective at all stages of the red palm weevil. The rates of effectiveness were 98.906%, 55.435%, 68.564% and 90.786% against egg, larva, pupa and adult stages, respectively. The results indicated that the effect of nanoparticles (ZnO, $TiO_2$ and CdS) is greater in egg and adult stages than larva and pupa stages of red palm weevil as shown in figure (14).

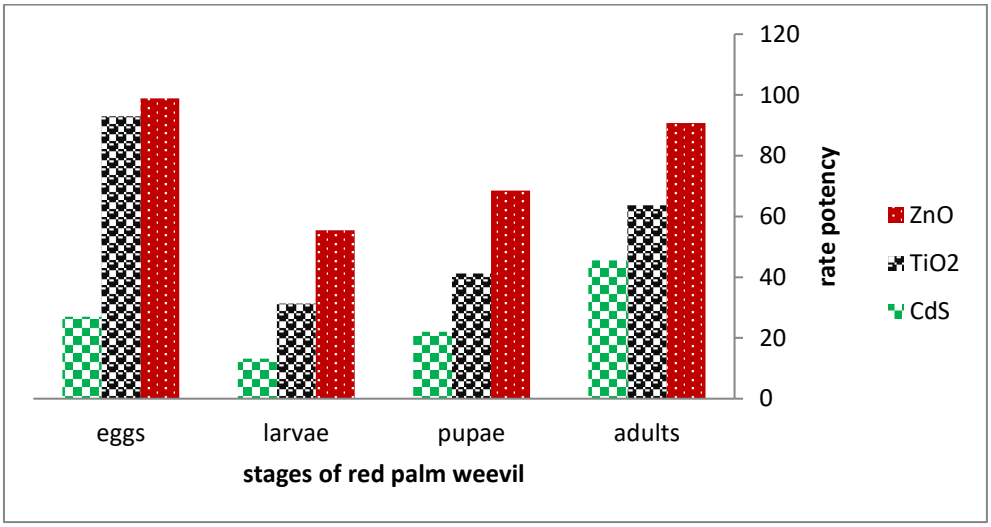


**Fig. 14:** Rates potency effected of ZnO, $TiO_2$ and CdS on all the red palm weevil stages.

## DISCUSSION

Nanotechnology is one of the most recent studies that have been used recently in many fields. In medicine, for example, it is used in the treatment of many diseases. It is also found in the field of agriculture as a catalyst for increasing the percentage of the crop. It is also used as a control for some agricultural pests.

In this study, the effect of three substances from nanoparticles was studied (ZnO, $TiO_2$ and CdS) against the red palm weevil under laboratory conditions. The results proved the effectiveness of the three types against all stages of red palm weevil as shown in the previous results. However, these compounds vary in their effectiveness against the red palm weevil, the author finds (ZnO) more effective at all stages of the red palm weevil and then comes ($TiO_2$) in the second rank and in the last rank comes (CdS). These results agreed with (Al-Barty and Hamza, 2015) used *Moringa oleifera* synthesized with titanium dioxide nanoparticles ($Tio_2$NPs) against the red palm weevil, the result showed that the synthesized $Tio_2$ NPs in low concentration was toxic against the red palm weevil larvae when compared with the aqueous extract of *Moringa oleifera*, the effect of *Morginga oleifera* synthesized with titanium dioxide nanoparticles increased the mortality of larvae. Solution ($Tio_2$NPs) caused 70.25% mortality of larvae after 8 days.

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## ARABIC SUMMARY

**اساليب تقنية النانو لمقاومة المراحل المختلفة لسوسة النخيل الحمراء، رينكوفورس فيروجينس عند تركيز موت النصف و التسعينى**

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سوسة النخيل الحمراء (رينكوفورس فيروجينس) ( غمدية الأجنحة: كركليونيدي) من أكثر الحشرات المدمرة للنخيل سواء نخيل البلح بأنواعة أو نخيل الزينة ولأهمية نخيل البلح في العالم وبالأكثر في الشرق الأوسط قمنا بهذة الدراسة التي تهدف إلى استخدام طرق حديثة لمكافحة سوسة النخيل الحمراء.

سوسة النخيل الحمراء عدو خفي يقضي معظم وقته ودورة حياته داخل جذوع النخلة وتقوم بالتغذية علي أنسجة الساق الداخلية للنخلة حتي تقضي عليها، والطور اليرقي هو الطور المدمر للنخلة وقد تظهر أجيال متتالية فى النخلة الواحدة، وقد انتشرت سوسة النخيل الحمراء في الآونة الأخيرة بصورة كبيرة في الشرق الأوسط.

في هذه الدراسة تم دراسة تأثير بعض مركبات النانو (أكسيد الزنك، ثاني أكسيد التيتانيوم و كبريتيد الكادميوم) على جميع مراحل نمو الحشرة (بيض و يرقة و شرنقة وحشرة كاملة ) في المعمل.

وقد أظهرت النتائج فاعلية المركبات الثلاثة ولكن بدرجات مختلفة، فكان تأثير (أكسيد الزنك) أقوي ثم يلية (ثاني أكسيد التيتانيوم) ثم ياتي في المرتبة الأخيرة ( كبريتيد الكادميوم).

أما معدل فاعلية أكسيد الزنك على (البيض - اليرقة - العذراء - الحشرة الكاملة) فكان (98,906 - 55,435- 68,564 - 90,786) % على التوالي, ثاني أكسيد التيتانيوم فكان (92,993- 31,268 - 41,252 -63,714) % على التوالي, أما كبريتيد الكادميوم على ( البيض- اليرقة –العذراء - الحشرة الكاملة ) فكان (27,024 - 13,227- 22,065 - 45,498 ) % على التوالي.