Biological activity of four plant oils, against the red palm weevil, Rhynchophorus ferrugineus (Oliver), (Coleoptera: Curculionidae)

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Abstract

In the present study, four botanical oils of *Melissa officinalis*, *Borago officinalis*, *Laurus nobilis* and *Carapichea ipecacuanha* were tested against newly emerged adult males and females of the red palm weevil, *Rhynchophorus ferrugineus* (Oliver) for investigating their insecticidal activity, their effects on some bilogical aspects and morphogenetic abnormalities in the all stages.The results revealed that the males of *Rhynchophorus ferrugineus* were more susceptible to the four botanical oils than the females, followed by the immature larvae. The larvae showed different degrees of susceptibility to the four botanical oils, they showed the highest susceptibility to *C. ipecacuanha* and the lowest to *B. officinalis* oil at LC_{50} levels. Both adult males and females showed the highest susceptibility to *C. ipecacuanha* and the lowest to *L. nobilis* oil at LC_{50} levels. Also, the obtained results showed that the four tested oils disrupted some biological aspects of the tested insects. These oils markedly reduced male and female longevity, female fecundity and hatchability of the laid eggs. Morphogenetic abnormalities such as darkness of pupae, incomplete adult eclusion , dwarfism and crumpled wings and legs of adults appeared in the different stages of the insect as a result of treatment with the four tested oils.

1 Introduction

The date palm, *Phoenix dactylifera* (Linn.), is the most important fruit crop in the Middle East. Date palm trees are liable to be attacked by many insect pests which cause serious damages to the different parts of the tree. The most serious insect pest namely, the red palm weevil, *Rhynchophorus ferrugineus* (Oliver) was first recorded in date palm plantations of Sharkia and Ismailia Governorates in Egypt by Saleh (1992).

Essential oils proved potential sources of alternative compounds to currently used fumigants. These oils have low toxicity to warm-blooded animals, high volatility and toxicity to stored-grain pests and weevils (Regnault-Roger and Hamraoui ,1995; Regnault-Roger, ,1997 and Shaaya et al. 1997).

Various chemical organic compounds have been isolated from plants, they include fixed oils, volatile oils and other plant constituents which expressed potential action against insect species. Extraction, isolation and identification of the fixed oils have been extensively studied by many authors (Abdallah et al. 1986; Moustafa et al. 1986; Baraka and EL-Hady 1993; Hussein and Shoukry, 1997; Shoukry – Karima, 2003). El-Sayed et al. (1989) found that maize oil and coconut oil when used against *Callosobruchus maculatus* reduced the progeny. Abdel-Kawy and Gharib (1991) stated that oils of cotton seeds, sesame and peanut showed efficiency in treatment of yellow meal corn against the rice weevil, *Sitophilus oryzae* (L.).Jood et al. (1993) used neem *(Azadirachta indica)* oil, powders of neem leaf and neem kernel, *Citrus limon* leaf, *Allium sativum, Mentha spichata* leaf in wheat grains at levels of 1% and 2% (w/w) against larvae of *Trogoderma granarium* Everts and they found that neem products completely prevented damage by an introduced larval populations. Adult emergence of *C. macculatus* was completely inhibited by castor oil, black seed oil and olive oil at concentration of 1% for 30 days (Swidan, 1996). Also, the essential oils were tested against many insect species (Bouda et al., 2001; Isikber et al., 2006).

The volatile oils of *Boxus chinensis* against 10 days-old larvae of the *R. ferrugineus* showed toxicological and pathological effects (Abdullah,2009).Huseyin et al., (2006) noticed that ethanolic extracts of some aerial parts of lamiaceae species showed high larvicidal activity after 24

hours and *M. officinalis* (Linn.) oil was the highest toxic against larvae of *Culex pipiens* Linn. Karahroodi-Zahra et al., (2011) investigated fumigant toxicity of six essential oils from *M. officinalis* (L.), *Mentha piperata* (L.), *Petroselinum sativum* (Hoffman), *Lavendula angustifolia* (Mill.), *Ziziphora clinopodioides* (Lam.), and *Artemisia dracunculus* (L.), on first instar larvae and eggs of *Plodia interpunctella* Hübner, they found that *M. officinalis* recorded moderate ovicidal activity. Ben Jemâa et al., (2011) studied the chemical composition and the repellent activity of *Laurus nobilis* essential oil against 7-10 days old-adults of the cigarette beetle, *Lasioderma serricorne.* They concluded that repellent action was highly dependent upon oil concentration and exposure time and *L.nobilis* essential oil may have potential as a control agent against this beetle. The essential oil of *B. officinalis* (L.) showed good larvicidal potential after 48 hrs of exposure period against *Anopheles gambiae* (Kweka *et al.*, 2012). Essential oil of *L. nobilis* showed strong fumigant toxicity against *Trogoderma granarium* larvae (Tayoub *et al.*, 2012).The ability of the aggregation pheromone to capture more females than males RPWs in the traps which makes trapping a potential tool for managing *R. ferrugineus* (El-Bokl *et al.,* 2015)

Morphogenetic abnormalities appeared in *Synthesiomyia nudiseta* stages including larval-pupal intermediate, deformed adults with crumpled wings or deformed thorax and abdomen when treated with the volatile botanical oil of *Cupressusma crocarpa* and *Alpina officinarum* (khalaf *et al.*, 2009).Powder of four plants, *B. officinalis*; *M. piperta; Officinalis anisum; Eucalyptus glubulus* was tested by Farman-Khansaa*, (2009*) against the red flour beetle, *Tribolium castaneum* and he found that *M. piperta* had most repellent efficiency plant, followed by *O. anisum, E. glubulus*, While the lowest was *B. officinalis.* In the present study, four botanical oils of *Melissa officinalis*, *Borago officinalis*, *Laurus nobilis* and *Carapichea ipecacuanha* were tested against newly emerged adult males and females of the red palm weevil, *Rhynchophorus ferrugineus* (Oliver) for investigating their insecticidal activity, their effects on some bilogical aspects and morphogenetic abnormalities in the all stages.

2 Materials and methods

The test insect:

Adult red palm weevils , *R. ferrugineus* were obtained from coccons collected from infested date palm trees in Sharkia and Dakahlia Governorates, incubated in an oblongate trans- parent plastic boxes (120 × 60 × 30cm) with easily removable perforated covers . These coccons were kept in wet toweling till adult emergence. The newly emerged adults were sexually differentiated and fed on small pieces of red palm core.

Tested plants:

The plants under investigation were originally obtained from local and international markets, identified, divided into two groups A and B, according to their constituents (fixed or volatile oils), these plants are listed in table (1)

Table (1): The tested plants.

Group	Tested plants		Family name	Used parts
	Common name	Scientific name		
Group (A) Fixed oils	Lemon balm	*Melissa officinalis*	**Lamiaceae**	Leaf
	Borage or Star flower	*Borago officinalis*	Boraginaceae	Leaf
Group (B)Volatile oils	Bay Laurel or Bay leaf	*Laurus nobilis*	Lauraceae	Leaf & fruit
	Rio ipecac عرق الذهب	*Carapichea ipecacuanha*	Rubiaceae	Root&leaf

Extraction of oils:

Extraction of the fixed oils was performed from crushed and previously steam distilled plant parts of group A, where the dry powdered plants were macerated in petroleumether (40/60) according to Harbourne, (1984) and El-Sayed *et al.*, (1989). The petroleum- ether extracts were filtered through anhydrous sodium sulphate. The solvent was removed by using rotary evaporator and the oils were stored under nitrogen gas until use.

The volatile oils were extracted from different parts of plants represented in table (1) group B, by using steam distillation technique according to the method of Anderson *et al.,* (1980). Then oils were saturated with sodium chloride and extracted again with diethyl ether .the extracts were dried over anhydrous sodium sulphate and evaporated under reduced pressure by using rotary evaporator apparatus.

Test method:

Serial concentrations of aqueous solution of the two groups of oils were prepared and (0.1% tween was added to the fixed oil as an emulsifier). Small pieces of date palm hearts were rinsed in each concentration for 20 seconds, then left to dry at room temperature. Treated pieces were put separately in all replicates of pairs of newly emerged adults or 10 days-old larvae of the second generation. For each concentration individuals of adults were counted after 10 days and after 7 days for larvae post treatments under laboratory conditions (30 ^{o}C., 75 ± 5% R.H., and 12D : 12 L hrs.) to determine the mortality percentage . Toxicity lines were established and LC$_{50}$ values were determined. The Toxicity lines were analyzed according to the method described by Finney (1952). The slope function and the relative potency of the tested oils were determined according to Sun (1950).

3 Results

Results in table (2) revealed that the *C. ipecacuanha* was the highest toxic to the larvae (LC$_{50}$=1264.09 ppm), followed by *L. nobilis* oil (LC$_{50}$=2424.32) and then *B. officinals* (LC$_{50}$=2518.91 ppm). The relative potencies based on C. *ipecacuanha* were 1.26 ,1.99 and 1.91 for *M.*

officinals, *B. officinals* and *L. nobilis*, respectively. The relatively low values of slope functions revealed

Also, the results in Table (2), showed that, the highest toxicity to the adult male weevil was satisfied to *C.ipecacuanha* (LC_{50} = 878.72ppm) followed by *M. officinalis*, *B. officinalis*oil then *L. nobilis*. The relative potencies of oils based on *C. ipecacuanha* oil were 1.29, 1.43 and 2.00 for *M. officinalis*, *B. officinalis* and *L. nobilis,* respectively. The relatively low values of slope functions revealed the homogenous response of the tested stages to the different concentrations of the tested oils.

Table (2): Toxicity and the Relative potency of the fixed and volatile oils against *R. ferrugineus*

Botanical oil	Tested plant	LC_{50} (ppm) (Confidence limits)	Slope function	Relative potency
10 days-old larvae:				
Fixed oils	Lemon balm *(Melissa officinalis)*	1604.642 (1279.837-2013.157)	2.335	1.269
Fixed oils	Borage (*Borago officinalis*)	2518.913 (2387.994-2657.587)	4.602	1.993
Volatile oils	Bay leaf (*Laurus nobilis*)	2424.323 (2298.722-2544.902)	5.253	1.918
Volatile oils	Rio ipecac (*Carapichea ipecacuanha*)	1264.097 (1035.893-1517.927)	2.571	1
Adult females:				
Fixed oils	Lemon balm *(Melissa officinalis)*	1290.569 (1144.586-1464.315)	2.022	1.207
Fixed oils	Borage (*Borago officinalis*)	1370.219 (1234.519-1509.268)	2.595	1.281
Volatile oils	Bay leaf (*Laurus nobilis*)	1899.779 (1783.881-2014.539)	4.452	1.776
Volatile oils	Rio ipecac (*Carapichea ipecacuanha*)	1069.534 (970.822-1179.14)	2.477	1
Adult males:				
Fixed oils	Lemon balm *(Melissa officinalis)*	1140.85 (1033.766-1262.715)	2.409	1.298
Fixed oils	Borage (*Borago officinalis*)	1259.165 (977.057-1528.304)	3.175	1.433
Volatile oils	Bay leaf (*Laurus nobilis*)	1758.669 (1449.213-2033.129)	4.436	2.001
Volatile oils	Rio ipecac (*Carapichea ipecacuanha*)	878.728 (783.846-979.989)	2.132	1

Data in table (3) showed a highly significant decrease in both male and female longevity of *R. ferrugineus* when treated with the plant oils of *M.officinalis* and *B.officinalis* as fixed oils; *L.nobilis* and *C. ipecacuanha* as volatile oils.

Also, the treatment with the tested plant oils of *M. officinalis*, *B. officinalis*, *C. ipecacuanha* and *L. nbilis* showed a high significant reduction on the fecundity.

Hatching percentage of eggs laid by adult females treated with the all tested oils decreased high significantly. The hatching percentages were 57.8±0.25% and 64.17±0.64% in case of treatment with *C. ipecacuanha*, and *L. nobilis* volatile oils, respectively. While the hatching percentages in case of treatment with the two fixed oils reached 59.8±0.2% in *M. officinalis* and 61.09±0.29% in *B. officinalis* oil.

Data in table (4) showed that, there was significant increase in larval duration in case of treatment with the volatile oils while statistical analysis of the decrease in the larval duration in case of treatment with the two fixed oils of *M. officinalis and B. officinalis* was not significant.

Significant increase in prepupal and pupal durations occurred by the treatment with *C. ipecacuanha* as it reached 7.2±0.88 and 11.85±1.12 days, respectively. While treatment with fixed oils of *M. officinalis and B. officinalis* decreased non significantly in the prepupal and pupal durations.

High significant reduction in the pupation percentage of treated larvae reached 42.33±0.33% by *C. ipecacuanha*, 56.12±2.6% by *M. officinalis*, 60.7±1.82% by *B. officinalis*,

Table (3): Effect of (LC$_{50s}$) of plant oils on biological aspects of newly emerged adults of *R. ferrugineus*

Treatment		LC$_{50}$ (ppm)		Adult longevity (days) Mean ± S.E.		Fecundity (eggs/) Mean ± S.E.	(eggs / /day) Mean ± S.E.	Fertility (eggs/) Mean ± S.E.	Hatching percentage (%) Mean ± S.E.
Control				143±3.05	134.67±3.48	150±2.31	2.49±0.04	137.33±0.67	91.58±1.04
Fixed oils	**Lemon balm** (*Melissa officinalis*)	1141	1291	78.33±4.41[**]	85.33±2.4[**]	95.33±2.91[**]	1.12±0.62[**]	57.0±1.73[**]	59.8±0.2[**]
	Borage (*Borago officinalis*)	1360	1370	97.0±4.58[**]	107.67±9.06[**]	120.0±2.89[**]	1.13±0.17[**]	73.33±1.76[**]	61.09±0.29[**]
Volatile oils	**Bay laurel** (*Laurus nobilis*)	1759	1900	105.67±3.17[**]	114.33±3.33[**]	136.67±3.33[**]	1.1±0.03[**]	87.67±2.03[**]	64.17±0.64[**]
	Rio ipecac (*Carapichea ipecacuanha*)	879	1070	60.67±3.48[**]	69.0±6.66[**]	77.33±9.33[**]	1.12±0.12[**]	44.67±5.24[**]	57.8±0.25[**]

Without * Non significant (P>0.05). * Significant (P<0.05).   ** highly significant (P<0.001)

and 61.22±2.4% by *L. nobilis*, while that, of control was 91.0±0.0%.

The treatment of 10 days old-larvae with (LC$_{50}$) of the two plant oils (fixed and volatile)resulted in high significant reduction of adult emergence (%).

Both male and female longevity also decreased significantly when treated by the two fixed and volatile oils and showed high significant decrease in their duration when treated with *C. ipecacuanha*. The tested plant oils had variable effects on fecundity of females emerged from treated larvae. The mean number of eggs deposited by a female decreased high significantly in case of treatment with *C. ipecacuanha* oil and was non-significant in case of treatment with *M. officinalis, B. officinalis and L. nobilis*.

Also, the data in table (4) showed non-significant decrease in hatching (%) of eggs laid by females emerged from treated larvae except that, of *C.ipecacuanha*, which showed a significant decrease. It was clear that, the plant oils (both the fixed and volatile) seriously disrupted some biological aspects of *R. ferrugineus* (Oliver).

Effect of plant extracts on the morphogenetic abnormalities:

Treatment of *R. ferrugineus* larvae with the tested plant oils resulted in pupae with various morphogenetic abnormalities. These abnormalities were represented by darkening of the pupae which differed from the normal pupae as shown in Fig (1). Almost of abnormal pupae died inside the cocoon, failed to emerge and changed to incomplete adult.

Table (4): Effect of (LC$_{50s}$) of plant oils on different biological aspects of 10 days - old larvae of *R. ferrugineus*

	Treatment	LC$_{50}$ (ppm)	Larval duration (days) Mean ± S.E.	Pupal stage				Adult Longevity (days) Mean ± S.E.		Fecundity Mean ± S.E.	Hatching (%) Mean ± S.E.
				Prepupal Duration (days) Mean ± S.E.	Pupal Duration (days) Mean ± S.E.	pupation (%)	Adult emergence (%)				
	Control	____	45.67±2.33	5.0±0.58	8.67±0.33	91.0±0.0	85.0±0.33	143±3.05	134.67±3.48	150±2.31	91.58±1.04
Fixed oils	(*Melissa officinalis*)	1605	38.4±1.8	3.8±0.24*	7.8±0.33	56.12±2.6**	55.12±3.2**	97.24±3.68**	109.28±2.1*	120.12±2.11*	79.2±0.67
Fixed oils	(*Borago officinalis*)	2519	40.5±2.6	4.5±0.67	8.0±0.25	60.7±1.82**	62.67±0.67**	118.23±2.33*	124.24±1.8	137.28±2.8	85.17±0.64
Volatile oils	(*Laurus nobilis*)	2424	56.33±2.14*	5.5±0.33	9.45±0.85	61.22±2.4**	66.67±2.28**	125.67±2.14*	127.33±2.33	142.67±2.33	87.12±0.29
Volatile oils	(*Carapichea ipecacuanha*)	1264	68.0±3.21**	7.2±0.88*	11.85±1.12*	42.33±0.33**	50.52±1.02**	80.0±5.12**	89.0±4.66**	100.67±3.67**	75.8±0.25*

Without * Non significant (P>0.05).   * Significant (P<0.05).   ** highly significant (P<0.001).

Fig. (1)Pupal deformation,
i-   Normal pupa of *Rhynchophorus ferrugineus*
ii-   Pigmentation of pupa due to volatile and fixed oil treatment

Fig. (2) Adult deformation,
i.Normal adult of *Rhynchophorus ferrugineus*
ii-Adult dwarfism due to volatile and fixed oil treatment

Fig. (3) Adult deformation,
i-   Normal adult of *Rhynchophorus ferrugineus*
ii-   Deformed adult with crumpled legs and wings due to volatile and fixed oil treatments

4 Discussion

From ecological point of view, insecticides of plant origin proved efficient, biodegradable as well as suitable alternative for palm weevils control. The control methods should aim at the weakest link of the life cycle of the weevil, which is the larval stage. The pest control methods were directed to the use of insecticides of plant origin. Plants are rich sources of bioactive compounds and offer an advantage over synthetic insecticides as are less prone to development of resistance, easily biodegradable and less toxic to natural environment. In fact many researchers have reported that essential oils of different plant extract having good larvicidal potentiality (Lee *et al.* 2001,Kotan *et al*. 2008, Koul *et al*, 2008).

Essential oils from various plants have shown promise as sources for insecticides. Earlier attempts to explore the toxicity of plant derivatives against *R. ferrugineus* have been made by essential oils. Nassar and Abdullah (2005) tested two natural insecticides, *Boxus chinensis*

oil and precocene II topically against larvae, prepupae and adult of red palm weevil, *R. ferrugineus* and the larvae of the palm beetle, *pseudophilus testsceous*. They found that larvae of   *R.   ferrugineus*   were   less tolerant to *B. chinensis* oil and more tolerant to precocene II than palm beetle larvae. Huseyin et al. (2006) studied the larvicidal activity of ethanolic extracts of some arial parts of Lamiaceae species against *Culex pipiens* (Linn.). They found that all plant extracts showed strong larvicidal activity after 24 hours exposure tests. *Melissa officinalis* (Linn.) oil showed the highest toxic activity. Abdullah (2009) tested the volatile oil of *Boxus chinensis* against 10-days old larvae of the red palm weevil, *R. ferrugineus*. He found that it had toxicological and pathological effects on *R. ferrugineus* larvae.

The present study revealed that the toxicity of the four botanical oils to the 10 days- old larvae and adults of *R. ferrugineus* showed that the (*C. ipecacuanha*) oil was superior to the other three oils of lemon palm (*M. officinalis*),Bay leaf (*L. nobilis*) and the borage (*B.*

officinalis) oils, while Borage showed the least toxic oil. The variation in the toxicological effects of the tested oils might be due to differences in their chemical composition as well as the variation in sensitivity and response to the various cells and tissues. This might also be depending on the amount of poison that reach the site of action. Mostafa *et al.* (1995) reported that the volatile oils of some plants increased the activity of Malic Dehydrogenase Enzyme (MDE) and decreased the activity of (Malic Enzyme) (ME) in *Pectinophora gossypiella* and *Erias insulana* larvae.

From the above mentioned data we concluded that the two fixed and the two volatile oils caused a similar significant decrease in both male and female longevities. This result agreed with Andronikashvili and Reichmuth (2003) who indicated that, the volatile oil of *L. nobilis* had high repellency effect towards adult of red flour beetle, *Tribolium castaneum* explaining its moderate insecticidal activity and reducing periods of male and female longevity. Similar results were obtained by Isikber *et al.* (2006). Farman-Khansaa (2009) investigated the repellent effect of powder of four plants; *B. officinalis, M. piperta, O. anisum* and *Eucaluptus glubulus* against the red flour beetles *Tribolium castanium*, reflecting the first essential reason of weevil longevities decrease, which is due to their high repellency.The same high repellency was recorded by Ben Jemâa *et al.* (2011) against adults of the cigarette beetle *Lasioderma serricorne*, also led to decrease in adult longevity. Also Mohamad *et al.*(2011) studied the causes of attraction and repellency effect of some plants extracts from leaves and roots of Borago and Tages plant against the Southern cowpea weevil, *C. maculates* (Fab.) and showed a significant differences in attraction and repellency effect according to the kind of extracted plant and concentration. When repellency occurs, it refers to the major reason of dramatical weevil longevity decrease. The same result was achieved by the volatile oil and this is agreed with Karahroodi-Zahra *et al.* (2009) who showed that, the volatile oils of *M. officinalis* had a moderate repellency against adults of *P. interpunctella* reflecting the first essential reason of weevil longevities decrease.

Also, the present study revealed that both fixed and volatile oils caused a significant decrease in both male and female longevities, a result confirmed by Andronikashvili and Reichmuth (2003) who indicated that, the volatile oil of *L. nobilis* had high repellency effect towards adult of red flour beetle, *T. Castaneum*. Similar results were obtained by Isikber *et al.* (2006).

The present study revealed that, fixed oils markedly decreased the average number of eggs deposited by treated females. This was confirmed by the findings of Schoonhoven (1978) and Shankaranarayana *et al.* (1979). Singh *et al* (1978) mentioned that, groundnut oil prevented the emergence of progeny rather than

affecting the oviposition of *C. maculates*. Abdel-Kawy and Gharib (1991) indicated that, cotton seed oil, sesame, peanut and paraffin oils reduced the number of progeny in *Sitophilus oryzae*. Taheya and Al-Moagel (1993) indicated that, tumeric extract reduced the khapra beetle F1 progeny, and interfered with its development. Regnault-Roger and Hamraoui (1995) showed that, the volatile oils of *L.nobilis* could protect kidney beans by direct or delayed insecticidal effect, through increased adult mortality and inhibition of beetle reproduction of *Acanthoscelides obtectus* (Say).

Also, we concluded that, the treatments by fixed and volatile oils had a significant effect on the reproductive potential of *R. ferrugineus* (Oliver). The average number of eggs laid per female as well as hatching (%) was reduced significantly. Similar results related to the fecundity of other treated insects with volatile oils were obtained by several authors (Frik and Nazirov 1981;Dongre and Rahalkar 1982).Nassar (1995) showed that, complete sterility of *Muscina stabulans* adult was achieved by larval treatment with some plant extracts and Hussein (1995) reported that, treatment of the second larval instar of *Parasarcophaga aegyptiaca* with some volatile plant oils induced a remarkable reduction in reproductive potential of developing adults. Shoukry- Karima (2003) stated that, the tested plant volatile oils of *Pipe rcubebae* and *Sativa officinalis* had a high significant decrease effect on pupation percentage, adult emergence percentage, fecundity, fertility and hatchability of females emerged from treated larvae of *P. interpunctella*.

In contrast, Singh *et al.* (1989) found that, volatile oils extracted from *Callicarpa macrophylla* and *Zanthoxylum alatum* plant increased the fecundity of *S. oryzae* and *Sitophilus granarius*. Karahroodi- Zahra *et al.* (2011) referred to the great toxicity of the volatile essential oils of *M. officinalis* against the first instar larvae and eggs of *P. interpunctella* leading to significant decrease in the number of hatched eggs. Karahroodi- Zahra *et al.* (2008) investigated fumigant toxicity of the essential oil from *M. officinalis* L. against first instar larvae and eggs, of *P. interpunctella* (Hübner) showing moderate ovicidal and egg deterrence effect against this pest. Nassar and Abdullah (2001), (2005) recorded some pupal morphogenetic abnormalities of the red palm weevil resulting in incomplete adult eclusion due to the treatment with azadirachtin and *Boxus chinensis*. The same result was also reported by Bream *et al.* (2001).

Most of the puparia failed to reach adults (aborted puparia). However, some emerged adults had various degrees of morphological abnormalities. Some individuals showed a dominance of incomplete adult eclusion, the emerged adults had some deformities varied between dorso-ventrally compressed body with collapsed appendages and complete dwarfism, Fig. (2) or with permanently expanded membranous wings,

failed to form elytra and appearance of pits on elytra, Fig. (3).

Similar results were obtained by Gujar and Mehrota (1983) who stated that, azadirachtin applied to the last instar of *Spodoptera litura* had juvenilizing effect and led to the formation of larval-pupal intermediate or incomplete adult eclusion. Abahussain (1999) studied the morphological effects induced by *Calotropis procera* in *C. pipiens* and *Anopheles multicator*, abnormal forms as larval- pupal and pupal-adult intermediates appeared.

The presence of dark stain in the weevil cuticle and immature pupae formation; both were symptoms of deficiency of juvenile hormone Nassar and Abdullah (2001) or the alteration in ecdysteroid and juvenoid titers. Another conceivable suggestion is that the tested oils may have indirectly affected the release of insect ecdysteroid, by interfering with the neuroendocrine sites of release of tropic hormones, especially the prothoracicotropic hormone (Bream *et al.* 2001). El-Bermawy and Abd el Fattah (2000) recorded that, using of plant extracts changed the protein within the fourth instar larvae of *T. confusum* which might have a biological role due to the role of DNA secreting enzymes which acted as catalyst in the metamorphosis. These studies confirm the results of present investigation related to morphogenetic effects on *R. ferrugineus* (Oliver). .

From the above mentioned data it was clear that, the plant oils, (fixed and volatile) seriously disrupted some biological aspects of *R. ferrugineus* (Oliver).

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