Egypt. Acad. J. Biolog. Sci., 5(1): 151-167 (2012) **A. Entomology**
Email: egyptianacademic@yahoo.com **ISSN: 1687–8809**
Received: 25/5/2012 **www.eajbs.eg.net**

Adulticidal activity of some botanical extracts, commercial insecticides and their binary mixtures against the housefly, *Musca domestica* L.

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ABSTRACT

The preliminary toxicity screening of 13 plant extracts against *Musca domestica* L. adult at 300 and 1000 ppm, revealed excluding both *Opuntia vulgaris* and *Saccharum* spp. which showed very low toxicity even at the higher concentration. Based on the obtained LD_{50} values for the eleven ethanolic extracts applied topically to the house fly adult, the extract of *Piper nigrum* showed the highest toxicity (LD_{50} = 0.115 ug/insect), while *Punica granatum* induced the lowest toxicity (LD_{50} = 0.278 ug/insect). Toxicity values of the other tested extracts ranged between the above mentioned values. For the tested insecticides, the LD_{50} values ranged between 0.00026 ug/insect for methomyl and 0.0013 ug/insect for flufenoxuron. Combining of 11 botanical extracts with 4 insecticides has resulted in 44 binary mixtures; all of them showed potentiating effects with different degrees. Moreover, mixing the insecticides at LC_0 (a concentration level causing no observed mortality) with the LC_{50} of each of the plant extracts have resulted in 44 paired combinations of high synergistic factor (S.F.). Based on the obtained RC_{50} values (repellent concentration for 50% of the tested house flies), the bioassayed extracts could be arranged with respect to their efficacy as follows: *Salix safsaf* (0.24 mg/cm^2)> *Conyza aegyptiaca* (0.25 mg/cm^2) > *Azadirachta indica* (0.28 mg/cm^2); followed by 5 extracts of the same RC_{50} value; 0.29 mg/cm^2 (*Cichorium intybus, Citrus aurantifolia, Piper nigrum*, *Sonchus oleracues* and *Zea mays*). The results of toxicity against adult stage of house fly by sugar bait method revealed that the most potent plant extract was *C. aegyptiaca* which showed LC_{50} value of 4.8 ppm, and the lowest one was *P. granatum* (LC_{50} = 10.4 ppm). Compared to the plant extracts, the tested insecticides showed very high toxicity; where the obtained LC_{50}s equaled to 0.60, 0.64, 0.66 and 0.74 ppm, respectively for deltamethrin, chlorpyrifos, methomyl, and flufenoxuron. The residual toxicity of the tested plant extracts and insecticides against the adult stage of *M. domestica* indicated that *C. aegyptiaca* possessed the highest t_{50} and t_{20} values (10.6 and 24.8 days, respectively). Dissipation of residual toxicity for the tested insecticides followed the following descending order: chlorpyrifos > deltamethrin > methomyl > flufenoxuron. The overall results of the present investigation reveal the broad-spectrum toxic properties of the tested plant extracts against *Musca domestica* adult; findings which may encourage further research on house fly control in tropics using indigenous plants.

Keywords: Housefly, Botanical biocides, Insecticides, Joint action, Repellent effects, Residual toxicity.

INTRODUCTION

The order Dipetra presents an array of insects which more than any other group poses the greatest challenge to human and veterinary health as vectors of diseases. One such insects, which share a close ecological niche with man is the house fly, *Musca domestica* Linnaeus (Diptera: Muscidae). Apart from disease transmission, *M. domestica* soils man's food and usually constitutes a nuisance, particularly the adult stage (Ande, 2001). House flies, occur throughout the tropics and are also found in warm temperate regions and some cooler areas. It is recognized as a serious public health pest to human beings and livestock by transmitting many infectious diseases (Khan and Ahmed, 2000). It acts as important mechanical carriers of pathogenic bacteria, such as *Shigella* sp, *Vibrio cholerae*, *Escherichia coli*, *Staphylococcus aureus*, and *Salmonella* sp. (Greenberg, 1973). Nevertheless, the common house fly has been extensively utilized as a test organism to screen candidate insecticides, chemosterilants and insect growth regulators by scientists in public or private research institutions.

Control measure against this insect in the short-term is the use of conventional insecticides (Cao *et al*., 2006; Malik *et al*., 2007). The indiscriminate use of chemical insecticides has given rise to many well-known and serious problems, such as the risk of developing insect resistance and insecticidal residual for humans and the environment (Ahmed *et al*., 1981). Insecticide resistance in house fly is a global problem and several surveys have shown that such resistance is wide spread and increasing (Georghiou and Mellon, 1983; Scott *et al*., 2000; Christensen *et al*., 2001). These problems coupled with the high cost of chemical pesticides have stimulated the search for biologically based alternatives. Accordingly, botanical insecticides based on natural compounds from plants, are expected to be a possible alternative. They tend to have broad-spectrum activity, relative specificity in their mode of action, and easy to process and use. They also tend to be safe for animals and the environment (Belmain *et al*., 2001). Several studies have shown the possibility of using plant extracts in the control of eggs, larvae, pupae and adults of *M. domestica* (Issakul *et al*., 2004; Malik *et al*., 2007).

The present study was undertaken to: a) test the potency of several plant extracts and some commercial insecticides against the adult stage of the house fly, *M. domestica*; b) analyze the joint action toxicity resulting from mixing botanical extracts with conventional insecticides; c) study the repellent efficacy of the prepared extracts; d) investigate the potency of the different substances against the insect adult using a "sugar bait" technique; and e) estimate the residual toxicity of the used plant extracts and commercial insecticides against the house fly adults.

MATERIALS AND METHODS

Test Insect

Musca domestica (MD) house flies were reared in the insect rearing room of our laboratory at 25-27°C, and 55-60% relative humidity. A standard rearing method (Sawicki, 1964) was adapted to provide adult flies of 0-24hrs old for running bioassay tests.

Plants

The following 12 plant species were used in the present study: *Azadirachta indica* A-Jus., *Cichorium intybus* L., *Citrus aurantifolia* L., *Conyza aegyptiaca* L., *Eucalyptus globulus* L. (fruits and leaves), *Opuntia vulgaris* L., *Piper nigrum* L.,

Punica granatum L., *Saccharum* sp., *Salix safsaf* Forsk., *Sonchus oleraceus* L., and *Zea mays* L. The used part of each plant is shown in Table 1. Dry seeds/fruits of neem (*A. indica*) and black pepper (*P. niger*) were procured from a spices supermarket, while the other plants were collected from the National Research Centre (NRC) farm. Subjected plant materials were washed, shade dried, chopped into small pieces or powdered and kept in suitable vessels until extraction.

Extraction

The method of Freedman *et al.* (1979) was adapted with minor modification. Samples of 100 g plant materials were extracted in a Soxhlet apparatus, using ethanol (75%) as solvent at a rate of 3 ml/g plant material and for 8 h extraction period. The solvent was evaporated to dryness under vacuum using a rotavapor with a water bath adjusted to 80°C. The crude residues were then weighed for estimating their yield percentages (Table 1) and kept in a deep freezer (-18ºC) until used.

Tested Insecticides

Four insecticides were used for comparison with plant extracts. These insecticides were Deltamethrin (Decamethrin®; 2.5% EC), Methomyl (Lannate®; 90% SP), Chlorpyrifos (Dursban®; 48% EC), and Flufenoxuron (Cascade®; 10% EC). These were purchased from Sidasa Company for Fertilizers, Pesticides and Chemicals, S.A.E., Cairo, Egypt.

Potency of Plant Extracts and Insecticides

Standard methods for the evaluation and testing of new insecticides by topical application (Wright, 1971) were followed with minor modifications. The houseflies were anaesthetized with diethyl ether for 5 minutes where 1µl of the test solution was applied by a Clinical Series pipette (CSP) on the dorsal thorax of 0-24 h-old adult house fly of mixed sexes selected randomly. Ten insects were used for each treatment and treatments were replicated four times. Each group of house flies was held in a -250 ml glass beaker covered with a muslin piece.

Preliminary tests were carried out at 300 and 1000 ppm (equivalent to 0.3 and 1.0 µg/insect, respectively) to exclude extracts of no or low observed toxicity, especially at the higher concentration. These tests revealed excluding both *Opuntia vulgaris* and *Saccharum* spp. (Table 1). A range of concentrations (0.10 – 2.0 ppm) and (100–300 ppm) were prepared for the tested insecticides and the rest of plant extracts, respectively. Solutions of insecticides were prepared in water while those of plant extracts prepared in 0.1% ethanol solution. The latter solution was found necessary to dissolve botanical extracts. Five concentrations of 4 replications each were usually tested for each studied substance along with control treatments dosed with the equivalent amount of ethanol solution free of the tested toxicants. All beakers were incubated at room temperature for 24 h, then percent mortalities were estimated and corrected according to Abbott's formula (Abbott, 1925). Probit analysis (Finney, 1971) was performed to estimate toxicity values (e.g., LD_{25}, LD_{50} and LD_{95}) and slope of regression line for each tested substance; using LD-P Software program.

Toxicity Bioassay by "Sugar Bait" Method

Quantities of 4.5g sugar with 0.5g of *curcuma longa* powder (turmeric) were placed in petri dishes and saturated with 1ml acetone containing the toxicant at definite concentrations and allowed to complete evaporation of acetone by electric air dryer. Control preparations were performed by equal quantities of sugar and turmeric plus acetone free of any toxicant. Each baited petri dish was placed in a rearing cage containing 10 adults of *Musca domestica* 0-24 h- old, and maintained at room temperature for 24 h. To estimate potency of the different substances, a range of concentrations (10-200 ppm for plant extracts) and (1-20 ppm for the insecticides)

were prepared to give a full scale concentration-mortality curves. These curves were used to determine the toxicity values (e.g., LC_{50} and LC_{95} values). Usually, four replications were carried out for each tested concentration alongside with control tests, and the toxicity results were referred to the amount of toxicant in ug/ 1g bait (i.e., ppm; w/w).

Residual Toxicity.

Quantities of sugar bait, each containing a tested toxicant at its respective LC_{95} value, were prepared as mentioned above. Baches of these baits were taken at different time intervals and introduced to adults of *Musca domestica* 0-24 h-old in the cages. Mortality was recorded after 24 h of exposure and bioassay of other batches was continued, at different time intervals, up to reaching lower mortality values (i.e.< 20 %) for each intoxicated bait. The obtained mortality was plotted versus time, to estimate the time required to reach 50% and 20% mortalities (i.e., t_{50} and t_{20} values in days) for each tested toxicant.

Repellency Action

The method used for testing repellent action of selected plant extracts, was mainly depended upon the recommended method in this respect (Wright, 1971). A quantity of 0.5g of each tested extract was dissolved in 1ml acetone in a Petri dish (9 cm in diameter). Acetone was allowed to evaporate in room temperature, leaving a homogeneous film on the petri dish, which was then placed in a wooden cage (20 x 20 x 20 cm) containing a piece of cotton saturated with milk. Adult flies (0-24 h- old) were trandferered to the cages and maintained in day light for 1h only.

Each experiment was replicated three times, and control tests were carried out alongside with treatments but with petri dishes containing acetone only. After the specified duration period, the number of fed and unfed adults (based on observing food in the gut) were counted and adjusted by Abbott's formula (Abbott, 1952):

$$\%\text{Repellency} = \frac{\%\text{ unfed in treatment} - \%\text{ unfed in control}}{100 - \%\text{ unfed in control}} \times 100$$

The promising candidates that showed 50% repellency or more were subjected to detailed studies to determine their RC_{25}, RC_{50} or RC_{95} values according to (Finney, 1971).

Mixtures Toxicity (Joint Action)

Paired mixtures of plant extracts with insecticides were freshly prepared at concentration levels of their respective LD_{25} values. Each mixture was tested in four replicates along with controls, and the tests were carried out as mentioned above. Mortality percentages were determined after 24 h and the combined (joint) action of the different mixtures was expressed as Co-toxicity factor according to Sun and Johnson (1960) to differentiate between potentiation, antagonism and additive, using the following formula:

Co - toxicity factor = (O – E) x 100/E; where:

O : is observed % mortality and E : is expected % mortality.

The co-toxicity factor differentiates the results into three categories. A positive factor of ≥ 20 indicates potentiation, a negative factor of ≤ -20 indicates antagonism, and the intermediate values of >-20 to < 20 indicate an additive effect. Because obtained LD_{25} values are mathematically estimated, they were tested again against MD adults to determine the accurate expected mortality. The expected mortality of the combined pair is the sum of the mortalities of single compounds at the given LD_{25} and

the observed mortality is the recorded mortality obtained 24 h after exposure to the mixture.

Synergistic/Antagonistic Action

These tests were carried out to determine the synergistic/antagonistic action resulted from mixing a definite amount of insecticide at the concentration level causing no observed mortality (e.g., LD_0) with a plant extract at its LD_{50} value. By comparing moralities obtained with the expected mortality of the mixture (ca. 50 %), the resulted synergistic/ antagonistic factor (SF) could give an indication to the nature of the effect (i.e. SF >1 means synergism; SF < 1 means antagonism; SF = 1 means no obvious effect). Each mixture was tested in four replications along with an untreated control test, according to the details mentioned above. Also, the expected mortality for the mixture was not considered as a 50 % kill, as in the original method (Thangam and Kathiresan, 1990). For more accuracy, it was obtained from experimental estimation in which mortality of each single toxicant (at the LD_0 & LD_{50} levels) was determined, summed and used as the expected mortality. A safety factor of ± 0.05 was considered when ranking the synergistic/antagonistic results (i.e. no obvious effect: SF = 1±0.05, synergism: SF >1.05, and antagonism: SF < 0.95).

RESULTS

Adulticidal Toxicity

The preliminary toxicity screening of the 13 plant extracts against *Musca domestica* adult at 300 and 1000 ppm, revealed excluding both *Opuntia vulgaris* and *Saccharum* spp. which showed very low toxicity even at the higher concentration (Table 1). Based on the obtained LD_{50} values for the eleven ethanolic extracts applied topically to the house fly adult, the extract of *Piper nigrum* showed the highest toxicity (LD_{50} = 0.115 ug/insect), while *Punica granatum* induced the lowest toxicity (LD_{50} = 0.278 ug/insect).

Table 1: Plants investigated for their toxicity to the adult stage of *Musca domestic*a showing used part, percent yield of crude ethanolic extracts and percent mortalities.

Plant (Family)	Used part	Yield of crude extract (%; w/w)	% Mortality at 1000 ppm (= 1.0 ug/insect)	% Mortality at 300 ppm (= 0.3 ug/insect)
Azadirachta indica A-Jus. (**Meliaceae**)	kernel	25.5	100.0	100.0
Cichorium intybus L. (**Asteraceae**)	Whole plant	25.0	100.0	100.0
Citrus aurantifolia L. (**Rotaceae**)	Fruit rind	41.3	100.0	100.0
Conyza aegyptiaca L. (**Asteraceae**)	Whole plant	25.0	100.0	100.0
Eucalyptus globulus L. (**Myrtaceae**)	fruits	29.7	100.0	100.0
Eucalyptus globulus L. (**Myrtaceae**)	leaves	49.9	100.0	100.0
Opuntia vulgaris L. (**Cactaceae**)	Fruit rind	19.2	1.7	0.0
Piper nigrum L. (**Piperaceae**)	seeds	10.5	100.0	100.0
Punica granatum L. (**Punicaceae**)	Fruit rind	8.0	100.0	90.1
Saccharum spp. (**Poaceae**)	Waste pulp	25.3	5.5	3.1
Salix safsaf Forsk. (**Salicaceae**)	leaves	30.2	100.0	100.0
Sonchus oleraceus L. (**Asteraceae**)	Whole plant	17.6	100.0	100.0
Zea mays L. (**Gramineae**)	Leaves & silk of ear	15.6	100.0	93.7

Toxicity values of the other tested extracts ranged between the above mentioned values. For the tested insecticides, the LD_{50} values ranged between 0.00026 ug/insect for methomyl and 0.0013 ug/insect for flufenoxuron (Table 2). The slope values of the LD-P lines accounted to 2.3, 4.3, 10.3 and 10.5 for methomyl, deltamethrin, chlorpyrifos and flufenoxuron, respectively; results indicating different degrees of homogeneity in the response of the tested insect to the above mentioned insecticides.

Table 2: Toxicity data for the tested ethanolic plant extracts and insecticides against adult stage of *Musca domestica*, as estimated after 24 h exposure times by using topical application method.

Tested plants & Insecticides	Toxicity values (ppm) and slope values (b)						
	LD_{25}		LD_{50}		LD_{95}		Slope
	ppm	µg/insect	ppm	µg/insect	ppm	µg/insect	
Azadirachta indica	112.1 (107.4-115.8)	0.112 (0.11-0.12)	128.1 (125.1-130.9)	0.128 (0.125-0.131)	177.3 (169.0-189.7)	0.177 (0.169-0.189)	11.7
Cichorium intybus	121.7 (118.3-124.6)	0.122 (0.122-0.124)	136.4 (133.9-139.1)	0.136 (0.134-0.139)	180.2 (172.5-190.9)	0.180 (0.173-0.191)	13.6
Citrus aurantifolia	201.3 (196.3-205)	0.201 (0.196-0.205)	216.3 (213.4-218.9)	0.216 (0.213-0.219)	257.5 (249.9-269.1)	0.258 (0.249-0.269)	21.7
Conyza aegyptiaca	113.7 (109.3-117.1)	0.114 (0.11-0.12)	129.2 (126.3-131.9)	0.129 (0.126-0.132)	176.5 (168.6-188.0)	0.177 (0.169-0.188)	12.1
Eucalyptus globulus (fruits)	162.4 (157.5-166.0)	0.162 (0.158-0.166)	177.7 (174.8-180.5)	0.178 (0.179-0.181)	221.3 (212.9-234.5)	0.221 (0.213-0.235)	17.3
Eucalyptus globulus (leaves)	161.6 (158.6-164.2)	0.162 (0.159-0.164)	174.1 (171.7-176.6)	0.174 (0.172-0.177)	208.5 (201.9-217.9)	0.209 (0.202-0.218)	20.9
Piper nigrum	100.9 (97.5-103.7)	0.101 (0.068-0.104)	115.4 (112.8-117.9)	0.115 (0.113-0.118)	160.1 (152.3-171.4)	0.160 (0.152-0.171)	11.6
Punica granatum	263.9 (260.0-267.1)	0.264 (0.260-0.276)	277.7 (275.1-280.1)	0.278 (0.275-0.280)	314.1 (308.9-321.1)	0.314 (0.309-0.321)	30.7
Salix safsaf	213.5 (208.9-217.1)	0.214 (0.209-0.217)	229.0 (226.2-231.7)	0.229 (0.226-0.232)	271.9 (265.3-281.2)	0.272 (0.265-0.281)	22.1
Sonchus oleraceus	140.6 (135.3-144.6)	0.141 (0.135-0.145)	157.3 (154.1-160.2)	0.158 (0.154-0.160)	207.0 (198.7-219.4)	0.207 (0.199-0.219)	13.8
Zea mays	261.3 (257.9-264.1)	0.261 (0.258-0.264)	275.2 (272.8-277.6)	0.275 (0.273-0.278)	312.0 (306.3-319.8)	0.312 (0.306-0.320)	30.1
Chlorpyrifos	0.96 (0.918-0.989)	0.00096 (0.0009-0.001)	1.1 (1.085-1.139)	0.0011 (0.0011-0.0014)	1.61 (1.531-1.705)	0.00161 (0.0015-0.0017)	10.3
Deltamethrin	0.33 (0.296-0.363)	0.0003 (0.0003-0.0004	0.48 (0.447-0.505)	0.00048 (0.00045-0.0005)	1.1 (1.0-1.376)	0.0011 (0.001-0.00138)	4.3
Flufenoxuron	1.14 (1.106-1.175)	0.00114 (0.0011-0.0012)	1.33 (1.296-1.356)	0.0013 (0.0013-0.0014)	1.9 (1.798-2.043)	0.0019 (0.0018-0.002)	10.5
Methomyl	0.132 (0.112-0.151)	0.000132 (0.000112-0.0002)	0.257 (0.232-0.284)	0.00026 (0.00023-0.00028)	1.3 (1.039-1.78)	0.0013 (0.0010-0.0018)	2.3

Potency of Plant Extracts and Insecticides Impregnated on Sugar Bait

The sugar bait prepared as mentioned above was found attractive to the insect flies to feed on it and control preparations caused no obvious mortalities, while preparations containing toxicants induced mortalities proportionate with gradual concentrations of the tested baits. The results of toxicity against adult stage of house fly by sugar bait method are shown in Table 3. Based on LC_{50} values, the tested plant extracts might be arranged in the following descending order: *C. aegyptiaca* > *S. oleraceus* > *C. intybus* > *A. indica* > *E. globulus* (leaves) > *P. nigrum* = *Z. mays* >*S. safsaf* >*E. globulus* (fruits) > *C. aurantifolia* > *P. grantum.* The slope of regression lines ranged between 1.9 for *C. aegyptiaca* extract and 3.9 for *E. globulus* (fruits). The most potent plant extract against the adult stage was *C. aegyptiaca* which showed LC_{50} value of 4.8 ppm and the lowest one was *P. granatum* (LC_{50} = 10.4 ppm). Compared to the plant extracts, the tested insecticides showed very high toxicity; where the obtained LC_{50}s equaled to 0.60, 0.64, 0.66 and 0.74 ppm, respectively for deltamethrin, chlorpyrifos, methomyl, and flufenoxuron. The slope values of the LC-P lines accounted to 2.7 for flufenoxuron and 2.3 for the other tested 3 insecticides (Table 3).

Residual Toxicity

The residual toxicity of the tested plant extracts and insecticides against the adult stage of *M. domestica* by sugar bait method at the level of LC_{95} values, as evaluated by mortality recorded at different intervals of time (days) due to exposure of

the insect adults to batches of sugar bait containing the toxicants, are presented in Table 4. The results are expressed in terms of the time required for mortality to decline to 50% (t_{50}) and (t_{20}). As example, the t_{50} for *A. indica* was found 7.8 days, while the t_{20} was 18.1 days. According to the obtained results, *C. aegyptiaca* recorded the highest t_{50} value (10.6 day), while the lowest t_{50} was entitled to *S. safsaf* (3.2 day).

Table 3: Toxicity data for the ethanolic plant extracts and insecticides against adult stage of *Musca domestica*, as estimated after 24 h exposure times by using the "sugar bait" method.

Tested plants & Insecticides	Toxicity values (ug/g bait or ppm; w/w) and slope of regression lines		
	LC_{50}	LC_{95}	Slope (b)
Azadirachta indica	6.6 (5.9-7.3)	29.0 (23.2-44.4)	2.5
Cichorium intybus	6.0 (5.5-6.5)	19.5 (16.6-24.4)	3.2
Citrus aurantifolia	9.6 (9.0-10.2)	28.0 (24.3-33.6)	3.5
Conyza aegyptiaca	4.8 (4.2-5.4)	35.3 (26.4-52.5)	1.9
Eucalyptus globulus (fruits)	9.2 (8.6-9.8)	24.6 (21.4-29.5)	3.9
Eucalyptus globulus (leaves)	6.7 (6.1-7.4)	29.7 (24.0-39.8)	2.6
Piper nigrum	7.5 (6.8-8.3)	33.6 (25.5-50.5)	2.5
Punica granatum	10.4 (9.7-11.1)	30.8 (25.8-39.1)	3.5
Salix safsaf	9.0 (8.3-9.8)	31.6 (25.9-41.6)	3.0
Sonchus oleraceus	5.0 (4.4-5.6)	30.5 (22.9-45.4)	2.1
Zea mays	7.5 (6.8-8.3)	37.8 (29.1-54.4)	2.3
Chlorpyrifos	0.64 (0.56-0.70)	3.30 (2.58-4.64)	2.3
Deltamethrin	0.60 (0.54-0.66)	3.24 (2.52-4.54)	2.3
Flufenoxuron	0.74 (0.68-0.81)	2.96 (2.48-3.76)	2.7
Methomyl	0.66 (0.60-0.74)	3.56 (2.76-5.12)	2.3

* Values between brackets are 95% fudicial limits of the corresponding toxicity values. The latter values are estimated from their respective regression lines (LC-P lines).

Also, *C. aegyptiaca* recorded the highest t_{20} value (24.8 day), and *S. safsaf* showed the lowest t_{20} value (5.9 day). Dissipation of residual toxicity for the tested insecticides followed the following descending order: chlorpyrifos > deltamethrin > methomyl > flufenoxuron. The estimated t_{50} values were 17.8, 12.5, 10.4 and 8.6 days, respectively, and t_{20} values were 31.3, 27.5, 21.0 and 15.5 days, respectively (Table 4).

Table 4: Dissipation of toxicity of plant extracts and insecticides impregnated on sugar bait and exposed to adult stage of *Musca domestica*.

Plant extracts & insecticides	Days required to reach	
	50% mortality (T_{50})	20% mortality (T_{20})
Azadirachta indica	7.8(6.8-9.2)	18.1(15.6-24.2)
Cichorium intybus	4.7(3.9-5.3)	9.4(8.2-11.3)
Citrus aurantifolii	4.9(3.9-6.02)	10.2(8.8-14.4)
Conyza aegyptiaca	10.6(8.9-14.7)	24.8(22.8-45.8)
Eucalyptus globulus (fruits)	3.9(3.6-4.2)	8.2 (7.3-9.4)
Eucalyptus globulus (leaves)	4.1(3.2-5.1)	10.9(9.2-16.1)
Piper nigrum	5.8(4.8-6.8)	13.0(11.3-16.6)
Punica granatum	4.8(3.5-6.7)	10.4(9.2-19.4)
Salix safsaf	3.2(2.5-3.9)	5.9(5.0-8.7)
Sonchus oleraceus	4.9(3.9-6.0)	10.2 (8.8-14.4)
Zea mays	6.8(5.2-9.0)	12.3(11.2-20.1)
Chlorpyrifos	17.8(24.3-37.1)	31.3(27.7-42.8)
Deltamethrin	12.5(10.6-14.5)	27.5(24.1-34.4)
Flufenoxuron	8.6(6.9-10.2)	16.5(14.2-21.2)
Methomyl	10.4(8.5-12.4)	21.0(18.2-27.5)

N.B.: T_{20} = the time required to reach 20% mortality.
T_{50} = the time required to reach 50% mortality.
*The used concentration (LC_{95}) was taken from Table (3).

Repellent Activity

Preliminary screening of repellent effect of 11 plant extracts against the adult of *M. domestica*, at a definite concentration, revealed superiority of 8 candidates causing repellency accounted to more than 50% (Table 5). These eight candidates were considered "promising" and thus subjected to detailed bioassay in order to estimate their repellent concentration (RC) values. Based on the obtained RC_{50} values (repellent concentration for 50% of the tested house flies), the bioassayed extracts could be arranged with respect to their efficacy in the following descending order: *S. safsaf* (0.24 mg/cm^2)> *C. aegyptiaca* (0.25 mg/cm^2) > *A. indica* (0.28 mg/cm^2); followed by 5 extracts of the same RC_{50} value, 0.29 mg/cm^2, (*C. intybus, C. aurantifolia, P. nigrum*, *S. oleracues* and *Z. mays*). At the RC_{95} values, both extracts of *C. aegyptiaca* and *S. safsaf* showed the highest repellency; accounting to 0.69 mg/cm^2 (Table 6).

Table 5: Preliminary screening of repellency/antifeedant effect of the tested ethanolic plant extracts on adult of *Musca domestica*, as tested at 0.5 g material on a filtter paper strip of 50 cm² area.

Plant extract	% of Unfed	% of repellency
Control	6.7	6.7
Azadirachta indica	90.7	90.0
Cichorium intybus	93.1	92.6
Citrus aurantifolii	89.1	88.3
Conyza aegyptiaca	95.0	94.0
Eucalyptus globulus (fruit)	47.1	43.3
Eucalyptus globulus (leaves)	49.0	45.3
Piper nigrum	90.0	89.3
Punica granatum	45.0	41.1
Salix safsaf	87.9	87.0
Sonchus oleraceus	93.9	93.5
Zea mays	90.0	89.3

*tested concentration = 10 mg/cm².

** % of repellency = $\frac{\text{\% of unfed in treatment - \% of unfed in control}}{\text{\% of unfed in control}} \times 100$

Table 6: RC_{25}, RC_{50}, RC_{95}, 95% fudicial limits and slope value for plant extracts against adult stage of *Musca domestica*

Plant extracts	RC values mg/cm^2 and fudicial limits (p< 0.05)			
	RC_{25}	RC_{50}	RC_{95}	Slope
Azadirachta indica	0.15 (0.12- 0.18)	0.28 (0.25-0.31)	1.32 (1.02-1.96)	2. 4
Cichorium intybus	0.19 (0.17-0.21)	0.29 (0.27-0.32)	0.88 (0.75-1.08)	3.5
Citrus aurantifolii	0.16 (0.13-0.19)	0.29 (0.27-0.32)	1.3 (1.01-1.89)	2.5
Conyza aegyptiaca	0.17 (0.15-0.18)	0.25 (0.23-0.27)	0.69 (0.61-0.82)	3.8
Piper nigrum	0.17 (0.14-0.19)	0.29 (0.26-0.31)	1.10 (0.87-1.4)	2.9
Salix safsaf	0.16 (0.14-0.18)	0.24 (0.22-0.26)	0.69 (0.60-0.82)	3.6
Sonchus oleraceus	0.17 (0.15-0.19)	0.29 (0.27-0.32)	1.1 (0.89-1.5)	2.9
Zea mays	0.18 (0.15-0.2)	0.29 (0.27-0.32)	0.97 (0.81-1.24)	3.2

Joint Action

The mixing of 11 botanical extracts with 4 insecticides has resulted in 44 binary mixtures. All the mixtures showed potentiation effects with different degrees according to the estimated co-toxicity factor. The results of joint action screening are presented, for the first time, in a form of a histogram (Fig. 1). The mixture of *Conyza aegyptiaca* + deltamethrin showed the highest co-toxicity factor (103.7), while the lowest co-toxicity factor (40.6) was entitled to the mixture of *Eucalyptus globulus* (fruits) + flufenoxuron. Nearly similar result was recorded for the mixture of *Eucalyptus globulus* (leaves) + flufenoxuron. Generally, all the tested plant extracts when mixed with any of the other 3 tested insecticides were resulted in potentiating mixtures of co-toxicity factors exceeding 90.0 (Fig. 1).

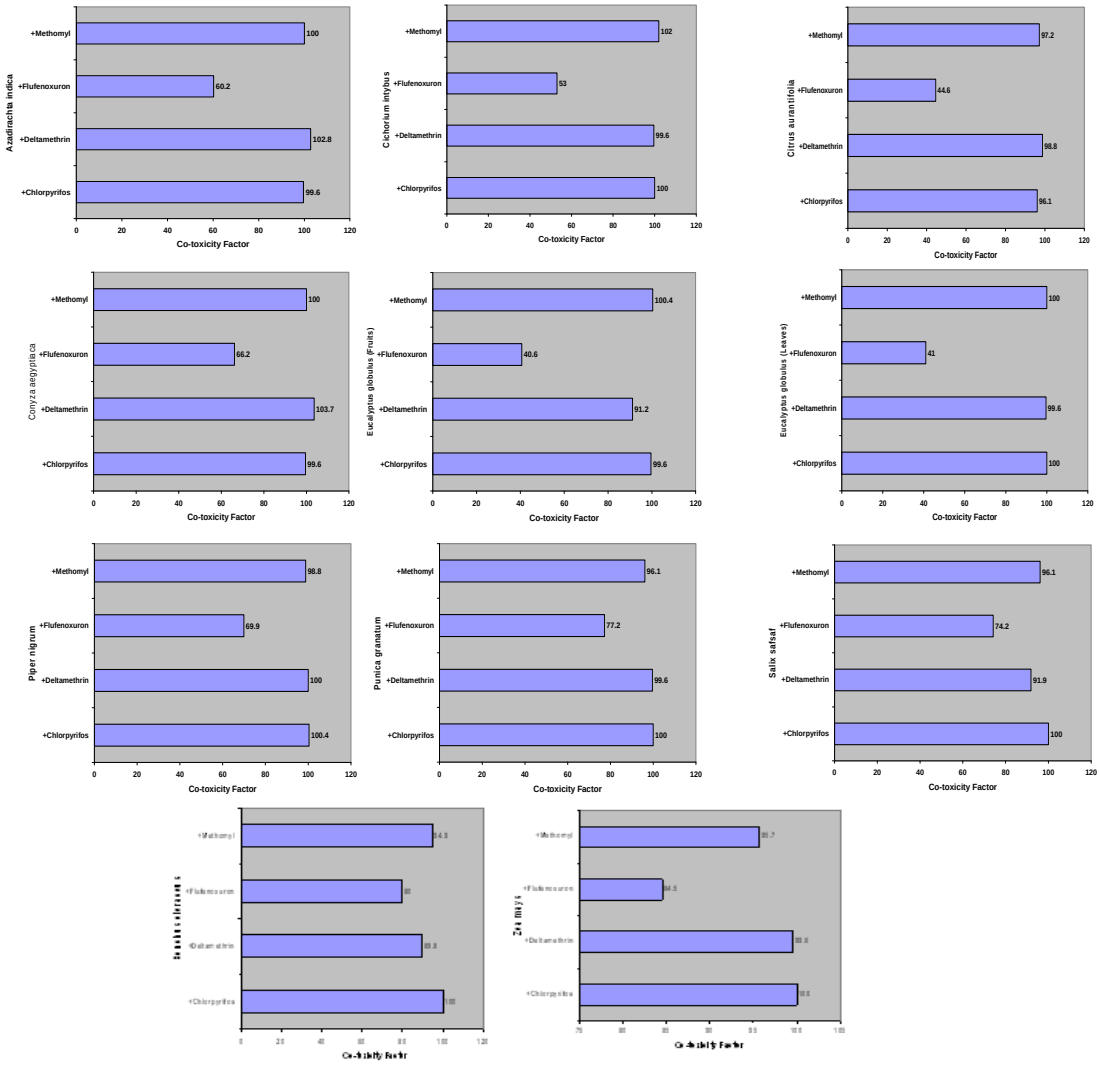

Fig. 1: Joint action of binary mixtures of botanical extracts with insecticides against adult stage of *Musca domestica* by topical application method.

N.B.: plant extracts and insecticides were mixed at 0.5ul of each containing the corresponding concentration of LD_{25} values.

$$\text{Co-toxicity factor} = \frac{\text{Observed \% mortality - Expected \% mortality}}{\text{Expected \% mortality}} \times 100$$

A positive factor of ≥ 20 indicates potentiation, a negative factor of ≤ -20 indicates antagonism, and the intermediate values of >-20 to < 20 indicate an additive effect.

Synergistic/Antagonistic Action

Combining 4 insecticides at LD_0 values with 11 plant extracts at LD_{50} values was resulted in 44 paired mixtures tested against the adult stage of *M. domestica*. The purpose was to test any possible synergism or antagonism for such toxicant combinations. According to the data presented in Table 7, all the mixtures induced synergistic toxicity against the concerned insect, but to varying degrees.

Table 7: Synergistic / Antagonistic effects resulted from mixing tested insecticides and plant extracts at LD_0 and LD_{50} concentration levels, respectively, as tested against adult sage of *Musca domestica* by topical application method.

Mixture		Tested conc		Sum of expected % mortality values [a)]	Observed % mortality for the mixtures [b)]	S.F.[c)]	Effect
Insecticides (A)	Plant extracts (B)	LD_0 ug/insect (A)	LD_{50} ug/insect (B)				
Chlorpyrifos	+*Azadirachta indica*	0.0005	0.128	50.0	90.1	1.8	Syn.
	+*Cichorium intybus*		136.4	50.0	91.3	1.8	Syn.
	+*Citrus aurantifolia*		216.3	51.3	93.9	1.8	Syn.
	+*Conyza aegyptiaca*		129.2	50.1	85.0	1.7	Syn.
	+*Eucalyptus globulus* (fruit)		177.7	50.1	87.7	1.8	Syn.
	+*Eucalyptus globulus* (leaves)		174.1	51.0	90.3	1.8	Syn.
	+*Piper nigrum*		115.4	50.0	89.7	1.8	Syn.
	+ *Punica granatum*		277.7	50.1	90.3	1.8	Syn.
	+*Salix safsaf*		229.0	50.0	95.0	1.9	Syn.
	+*Sonchus oleraceus*		157.3	50.3	93.7	1.9	Syn.
	+*Zea mays*		275.2	50.2	90.7	1.8	Syn
Deltamethrin	+*Azadirachta indica*	0.00006	128.1	51.0	90.9	1.8	Syn.
	+*Cichorium intybus*		136.4	50.3	90.0	1.8	Syn.
	+*Citrus aurantifolia*		216.3	50.1	95.1	1.9	Syn.
	+*Conyza aegyptiaca*		129.2	50.1	93.9	1.9	Syn.
	+*Eucalyptus globulus* (fruit)		177.7	50.0	90.0	1.8	Syn.
	+*Eucalyptus globulus* (leaves)		174.1	50.1	90.1	1.8	Syn.
	+*Piper nigrum*		115.4	51.3	91.9	1.8	Syn.
	+ *Punica granatum*		277.7	50.0	90.5	1.8	Syn.
	+*Salix safsaf*		229.0	50.0	91.9	1.8	Syn.
	+*Sonchus oleraceus*		157.3	51.0	93.1	1.8	Syn.
	+*Zea mays*		275.2	50.7	90.3	1.8	Syn
Flufenoxuron	+*Azadirachta indica*	0.0006	128.1	50.1	85.5	1.7	Syn.
	+*Cichorium intybus*		136.4	51.3	83.9	1.6	Syn.
	+*Citrus aurantifolia*		216.3	50.7	85.0	1.7	Syn.
	+*Conyza aegyptiaca*		129.2	50.0	85.1	1.7	Syn.
	+*Eucalyptus globulus* (fruit)		177.7	50.3	81.9	1.6	Syn.
	+*Eucalyptus globulus* (leaves)		174.1	50.1	87.1	1.7	Syn.
	+*Piper nigrum*		115.4	50.0	80.0	1.6	Syn.
	+ *Punica granatum*		277.7	50.0	83.9	1.7	Syn.
	+*Salix safsaf*		229.0	50.1	85.1	1.7	Syn.
	+*Sonchus oleraceus*		157.3	50.0	83.1	1.7	Syn.
	+*Zea mays*		275.2	49.9	85.0	1.7	Syn.
Methomyl	+*Azadirachta indica*	0.0001	128.1	50.0	91.9	1.8	Syn.
	+*Cichorium intybus*		136.4	50.3	90.7	1.8	Syn.
	+*Citrus aurantifolia*		216.3	50.7	90.5	1.8	Syn.
	+*Conyza aegyptiaca*		129.2	50.2	89.0	1.8	Syn.
	+*Eucalyptus globulus* (fruit)		177.7	50.1	90.0	1.8	Syn.
	+*Eucalyptus globulus* (leaves)		174.1	50.0	91.9	1.8	Syn.
	+*Piper nigrum*		115.4	50.3	90.9	1.8	Syn.
	+ *Punica granatum*		277.7	49.7	95.0	1.9	Syn.
	+*Salix safsaf*		229.0	50.1	97.1	1.9	Syn.
	+*Sonchus oleraceus*		157.3	50.3	92.3	1.8	Syn.
	+*Zea mays*		275.2	49.9	93.9	1.9	Syn

N.B.; (a) Expected mortalities resulted from exposing *Musca domestica* larvae to LD_0 and LD_{50} of the tested toxicants in separate tests. (b) Observed % mortality refers to that of the mixture tested in the same experimental container at the LD_0 and LD_{50} levels. (c) S.F. means synergistic/antagonistic factor which resulted from dividing the observed values by practical expected values; where S.F. = 1.0 ± 0.05 (no effect); S.F. > 1.05 (synergism); S.F. < 0.95 (antagonism).

The highest synergistic factor (S.F.) was 1.9 for the following mixtures: chlorpyrifos + *Salix safsaf*; chlorpyrifos + *Sonchus oleraceus*; deltamethrin + *Citrus aurantifolia*; deltamethrin + *S. oleraceus*; methomyl + *Punica granatum*; methomyl + *S. safsaf*; and methomyl + *Zea mays*. The lowest S.F. value (1.6) was resulted from combining the insect growth regulator (IGR) compound, flufenoxuron, with any of the following plant extracts: *Cichorium intybus*, *Eucalyptus globulus* (fruits), and *Piper nigrum*. The rest of the tested mixtures showed S.F. factor ranging between 1.7 and 1.8 (Table 7).

DISCUSSION

The co-evolution of plants with insects has equipped them with a plethora of chemical defenses, which can be used against insects. Since botanicals are less likely to cause ecological damage, a large number of plants have been screened for their insecticidal activities against different insect pests and some of these have been found to be promising, specifically, on related Dipterans (Dhar *et al.*, 1996; Promsiri *et al.*, 2006; Malik *et al.*, 2007). Botanical products have become more prominent in assessing current and future pest control alternatives, (NRC 2000). Over the past two decades, surveys of plant families (Lydon and Duke 1989; MacKinnon *et al.*, 1997) have discovered sources of new botanical insecticides, which could possibly meet some of the desired demands.

Identification of novel effective muscacidal compounds is essential to combat increasing resistance rates, concern for the environment and food safety, the unacceptability of many organophosphates and organochlorines and the high cost of synthetic pyrethroids. To be highly competitive and effective, the ideal phytochemical should possess a combination of toxic effects and residual capacity. Acute toxicity is required at doses comparable to some commercial synthetic insecticides while chronic or sub-chronic toxicity is required to produce growth inhibition, developmental toxicity and generational effects (Shaalan *et al.*, 2005).

The effectiveness of an insecticidal treatment is influenced not only by the toxicity of the insecticide but also by the primary response of the insect to its mode of application. Repellent or attractant effects are the principal factors affecting insecticidal efficiency and many common insecticides exhibit one or both of these properties depending on concentration. Odour of most insecticides is repellent to certain insects at higher concentrations but act as attractants at lower concentrations (Dethier, 1954).

The selected botanicals in the present study (Table 1), included five plant species from agricultural wastes (e.g., *Opuntia vulgaris, Zea mays, saccharum spp.,Punica granatum, Citrus aurantifolia*), three weeds (e.g., *Cichorium intybus, Conyza aegyptiaca, Sonchus oleraceus*), three ornamental trees (e.g., *Azadirachta indica*, *Eucalyptus globulus, Salix safsaf*), and one agricultural crop (e.g., *Piper nigrum*). All of the selected plant candidates are easily obtainable locally. Among the selected plants, two candidates (e.g., *A. indica* and *P. nigrum*) are often considered the most promising and bioactive (Grainge and Ahmed, 1998) and thus could be used for comparative purposes with the other tested plants.

The toxicity of the tested plant extracts was evaluated by two different methods; namely topical application and sugar bait. The basis for toxicity by topical application of plant extracts to house flies has been fairly documented (Malik *et al.,* 2007), and may indicate possible neurotoxic action of the active constituents of the plant species that is mainly related to the acetycholinesterase and octopaminergic levels (Isman

2000; Kostyukovsky *et al*., 2002), or the active constituents may transform the alcohol present into the fly body into the corresponding esters (Tsao and Coats, 1995). The insects fed on the sugar lure are mainly exposed to stomach poisoning action; however exposure through contact could not be overcomed.

In topical application tests conducted in the present investigation, ethanolic extracts of *A. indica* and *P. nigrum* showed LD_{50} of 0.128 and 0.115 ug/insect, respectively (Table 2). The extract of *C. aegyptiaca* showed LD_{50} value (0.129 ug/insect) very close to that of *A. indica*. In "sugar bait" tests, the superiority of *C. aegyptiaca* over *A. indica* and *P. nigrum* was pronounced. The obtained LC_{50} values for the ethanolic extracts of these plants were 4.8, 6.6 and 7.5 ppm, respectively (Table 3). Also, *S. oleraceus* extract showed LC_{50} of 0.5 ppm; a value ranking it after *C. aegyptiaca*. Such results may shed light to the investigated potency of both *C. aegyptiaca* and *S. oleraceus* , and give an indication to the potency with respect to route of exposure which was *via* contact in the topical application tests , while *via* oral (and contact) in the "sugar bait" tests. Interestingly, the extract of *C. aegyptiaca* showed residual toxicity accounted to 10.6 and 24.8 days, in terms of t_{50} and t_{20} values, respectively; which were higher than those of *A. indica* (t_{50} = 7.8 days and t_{20} = 18.1 days), and nearly approaching the values obtained for the tested synthetic insecticides (Table 4).

In this respect, it may be convenient to mention that chloroform extract of *Curcuma longa* was reported to act as repellent to *Tribolium castaneum* (Herbst) adults (Abida *et al*., 2010), and to cause 85% mortality to the peach fruit fly, *Bactrocera zonata* (Diptera: Tephritidae), fed on diet containing 1000 ppm of acetone extract (Siddiqi *et al*., 2011). The addition of turmeric to sugar in our experiments didn't repel or kill the house fly adult, and may mask the odour of the tested toxicants. Furthermore, turmeric gave sugar a yellowish colour as a warning sign. Our investigated "sugar bait" may be considered as a trial for simple formulation likely to resemble the "Novartis Snip® Fly Bait" which is a professional trade mark fly bait formula containing a house fly sex attractant [(Z)-9-tricosene; 0.02%] and the insecticide Azamethiphos (1.0%) [http://www.drugs.com/vet/snip-fly-bait-can.html].

Mortality caused by the different plant extracts to the adult of *M. domestica* might be due to the differential toxicity of the active ingredients. The varying results were probably due to the differences in levels of toxicity among the insecticidal ingredients of each plant (Monzon *et al.*, 1994), apparently the plant alkaloids (Saxena *et al.*, 1993). Studies have also established that the activity of phytochemical compounds on target species varies with respect to plant parts from which they are extracted, solvent of extraction, geographical origin of the plant and photosensitivity of some of the compounds in the extract, among other factors (Sukumar *et al.*, 1991). Our study also show that leaf extracts of *E. globulus* seemed to be more potent than the fruit extracts (Tables 2, 3 & 4). Eucalyptol, one of the principle constituents in *E. globulus*, has been reported to be very toxic to male house fly at LD_{50} of 118 µg/fly (Sukontason *et al*., 2004). According to our results, the crude ethanolic extract of this plant showed very lower LD_{50} value against adult house fly without sex differentiation (0.174 µg/fly for leaf extract and 0.178 µg/fly for fruit extract; Table 2). Such very big difference in the toxicity values may refer to other toxic substances in the crude extract and the susceptibility of the insect strain used in our study. Also, with respect to our study's concern, the essential oil of *Citrus sinensis* was found the most potent among 12 oils against the adult stage of *M. domestica*, recording LC_{50} of 3.9 mg/dm³. GC/MS analysis revealed that limonene (92.47%), linalool (1.43%) and β - myrcene (0.88%) were the principal components of the essential oil of *C. sinensis* (Palacios *et*

al., 2009). Many studies have drawn attention to the toxic effects of plant extracts on Dipterans with respect to the different plant constituents and tolerance levels of the tested insects (Dhar *et al*., 1996; Cao *et al*., 2004; Promsiri *et al*., 2006; Malik *et al*., 2007).

In paralleled studies, ethanolic extracts of *P. nigrum*, *A. indica, C. aegyptiaca* and *C. intybus* were found to possess the highest potency among the bioassayed candidates against the larval stage of *M. domestica*, in addition to producing different forms of developmental effects to the treated larvae (Mansour *et al*., 2011). Also, the same plant extracts were shown high potency against larvae and adults of the mosquito *Anopheles pharoensis* (Mansour *et al*., 2010). Therefore, the results of the present investigation, in addition to our recent findings (Mansour *et al*., 2010 & 2011), reveal the broad-spectrum toxic properties of the tested botanicals against the concerned Dipterans insects.

Repellent and attractant properties of natural oils and various plant extracts on *M. domestica* have been documented by Braverman and Hogsette (2001). There was a considerable variation in the repellent action of the different botanicals used in the present study and this may reflect the complexity of the phytochemical composition of the materials tested. For instance, some of the tested extracts (e.g., *C. aegyptiaca*, *S. safsaf, C. intybus and Z.mays*) were found to induce high repellency to the house fly adult more than *A. indica* and *P. nigrum* extracts (Table 6). The concentration required to repel 95% (RC_{95}) for the above mentioned five plants was estimated as 0.69, 0.69, 0.88, 0.97, 1.32 and 1.10 mg/cm^2, respectively.

Organophosphorus (e.g., chlorpyrifos) and carbamate (e.g., methomyl) insecticides are toxic to insect and mammals by virtue of their ability to inactivate the enzyme acetylcholinesterase, which is a class of enzymes that catalyzes the hydrolysis of the neurotransmitting agent acetylcholine (Ach); leading to poisoning (Fukuto, 1990). Synthetic pyrethroids (e.g., deltamethrin) are generally recognized as neurotoxicants that act directly on excitable membranes related to their ability to modify electrical activity in various parts of the nervous system. This effect is caused by a sterioselective and structure-related interaction with voltage-dependent sodium channels, the primary target site of the pyrethroids (Vijverberg *et al*., 1982). Flufenoxuron is an acylurea insect growth regulator which kills insect pests through interference with chitin formation (Cutler *et al*., 2007).

Commercial synthetic pesticides are products specifically prepared at defined active ingredient (a.i.) contents to affect pests at very low concentrations. Crude plant extracts contain several phytochemicals of different biopesticidal activity. The active ingredient(s) responsible for potency are usually present in very little concentrations compared to those of traditional synthetic pesticides. Such difference has to be taken into account when comparing biocidal activity of botanicals with chemical pesticides. The data presented in this investigation (Tables 2, 3, 4) may possibly be used for comparison purposes. For example, based on sugar bait-LC_{50} values (Table 6), the potency of chlorpyrifos, deltamethrin, flufenoxuron and methomyl relative to the *C. aegyptiaca* extract equals 7.5, 8.0, 6.5 and 7.3 folds, respectively.

The residual toxicity of a pesticide, for a specific short period, after application is required to achieve higher degree of pest control; especially for insects of frequent visiting to the sprayed area such as house flies, mosquitoes, cockroaches and other pests of medical importance. Several reports were published on agricultural insects; such as *Spodoptera littoralis* (Meisner *et al*., 1981), and the mite *Amblyscius follacis* (Bostanian *et al*., 1985). Chavan (1984) reported the residual activity of the neem fraction NP-2 against mosquitoes and found the product was effective up to 9 days

(68% mortality) at 100 ppm. Such results are comparable with ours in which mortality caused by *Azadirachta indica* extract to the adult house fly was declined to 50% after 7.8 days of its application (Table 4).

Most studies on the synergistic, antagonistic and additive toxic effects of binary mixtures involving phytochemicals have been conducted on agricultural pests rather than pests of medical importance. In an attempt to explain synergistic activity involving phytochemicals, Thangam and Kathiresan (1991) surmised that synergism might be due to phytochemicals inhibiting the insect ability to use detoxifying enzymes against synthetic chemicals. Identifying these synergist compounds within mixtures may lead to the development of more effective biopesticides as well as the use of smaller amounts in the mixture to achieve satisfactory levels of efficacy. Indeed, joint-action may well prolong the usefulness of synthetic insecticides that will eventually be unusable due to resistance (Shaalan *et al.*, 2005). Synergistic action with conventional chemical pesticides determined in the present study could be exploited for integrated pest management (IPM) programs.

The results of the present investigation reveal the broad-spectrum toxic properties of the tested botanical extracts against the adult stage of *M. domestica*. The interesting result is the efficacy of the extracts against adults as both toxicant and repellent. Their repellent action can be exploited for adult house fly control by developing proper volatile delivery strategies. Synergistic action with conventional chemical pesticides determined in the present study could be exploited for integrated pest management (IPM) programs. The developed "sugar bait" technique is simple and promising enough to encourage for further investigations.

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ARABIC SUMMARY

النشاط الأبادي لبعض المستخلصات النباتية والمبيدات التجارية ومخاليطها المزدوجة ضد الطور البالغ للذبابة المنزلية

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أسفرت الغربلة الأولية لثلاث عشرة مستخلصا نباتيا ضد الذبابة المنزلية في اختبارات تمت علي تركيز 300 ، 1000 جزء في المليون عن استبعاد كلا من قشور ثمرة التين الشوكي ، مصاصة القصب لانخفاض سميتها حتي علي التركيز الأعلي . وفي الأختبارات التفصيلية بطريقة المعاملة السطحية للذباب أظهر المستخلص الكحولي لبذور الفلفل الأسود أعلي سمية حيث سجلت قيمة الجرعة النصفية المميتة (ج ق$_{50}$) 0.115 ميكروجرام / حشرة ، بينما كان مستخلص قشور الرمان الأقل سمية (ج ق$_{50}$ = 0.278 ميكروجرام / حشرة) ، وتراوحت قيم ج ق$_{50}$ للمبيدات المختبرة مابين (0.00026) و (0.0013) ميكروجرام / حشرة وذلك بالنسبة لمبيد الميثوميل ومبيد الفلوفينوكسيورون علي التوالي . وبخلط إحدي عشر مستخلصا نباتيا مع أربعة مبيدات علي مستوي ج ق$_{50}$نتج أربعة وأربعون مخلوطا أعطت جميعها تأثيرا سميا تنشيطيا بدرجات متفاوتة ، وحدث نفس الشيئ عندما استخدمت النباتات بتركيز غير مميت مع التركيز النصفي القاتل من النباتات ، وهذا دل علي أن إضافة المستخلصات النباتية للمبيدات الكيميائية أدي إلي تنشيط التأثير السمي للأخيرة . وفي اختبارات التأثير الطارد للمستخلصات النباتية جاء ترتيب الفعالية وفق التالي: نشاش الذباب > النيم > الشيكوريا ، النارنج ، الفلفل الأسود ، الجعضيض ، الذرة. وفي الأختبارات بطريقة طعم السكر المحمل بالمبيد كان مستحضر نشاش الذباب الأكثر سمية حيث سجل التركيز النصفي المميت (ت ق$_{50}$) 4.9 جزء في المليون وكان مستخلص قشور الرمان الأقل سمية (ت ق$_{50}$= 10.4 جزء في المليون) وبالمقارنة كانت المبيدات الكيميائية المختبرة متفوقة في سميتها بشكل كبير. كما أظهر مستخلص نشاش الذباب أعلي فترة ثبات سمي قدرها 10.6 يوم ، 24.8 يوم حتي انخفاض السمية إلي مستوي 50% ، 20% علي التوالي – أما المبيدات فقد أظهرت المسلك التالي من حيث مدة بقاء التأثير السمي لها: كلوربيريفوس > دلتامثرين > ميثوميل > فلوفينوكسيورون . وتخلص النتائج إلي توصل الدراسة الراهنة إلي الكشف عن الفعالية البيولوجية لعديد من النباتات ضد حشرة الذبابة المنزلية - الأمر الذي يدعو إلي المزيد من الدراسات في هذا الأتجاه بهدف استخدام النباتات المحلية في مكافحة الذبابة المنزلية.