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Determination of Insect Infestations and Their Losses on Some Stored Medicinal Plants

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Abstract: The study aimed to estimate the infestation of insect pests and their losses on eight medicinal plants collected from Sekem Company (SC) (Belbeis, Sharkia) and Royal Company (RC) (Shabramant, Giza) in Egypt. Seeds of five Apiaceae plants: anise, caraway, coriander, cumin and funnel as well as dried leaves of two Lamiaceae plands: basil and mint addition to flowers of chamomile plant (Asteraceae) were collected one-month post harvest and stored under room temperature from Jun to December 2012. Results should that the main insect pest on anise is the fennel wasp *Systole* sp. causing the most loss in the anise collected from both companies. Low numbers of *Lasioderma serricorne, Tribolium castaneum* and *Oryzaephilus surinamensis* were found and they caused together low losses (1.2-2.9%) in SC mint. While, in RC mint, *L. serricorne* and *Systole* sp were recorded with losses less than 4.7%. *Lasioderma serricorne* was also the main insect pests on chamomile beside few numbers of *T. castaneum*, *O. surinamensis* and *Systole* sp causing 15.8% loss at SC. The same insect pests were found in RC (excepting *Systole* sp.) with lower infestation and losses (0.8- 2.0%). Basil could be infested by *L. serricorne* as the main insect pest that cause significant losses at the two companies beside few numbers of *T. castaneum* and *O. surinamensis*. The fennel wasp was responsible for losses on cumin at SC. The main insect pest of coriander was *L. serricorne* causing losses up to 13.4% at SC. Caraway and fennel were infested by only *Systole* causing low losses (0.4-5.8%) and 1.0-5.4%, respectively at RC.

Key words: Bio-products · *Lasioderma serricorne* · Botanicals · *Oryzaephilus surinamensis* · *Systole* sp. · *Tribolium castaneum*

INTRODUCTION

The medicinal plants occupy a great position among the plants related to their importance in many economical purposes. One of the important economically is production of the essential oils. These oils are used for many pharmaceutical industries and medical applications for wide range of human and animal diseases. Moreover, the essential oils are also used for foods, beverage, spices and aleo-resin of the aroma and flavor industry [1].

In Egypt, the increasing of the population growth led to use all available resources for the production of food and natural drugs from medicinal plants for local market and to open world markets widely to export the production and then the Egyptian economically situation will be improved. Using the organic cultivation helps to open the European and other world markets for the Egyptian products. Many companies and exporters produce medicinal plants and food stuffs by the organic cultivation without using any chemicals in all cultivation process.

On the other hand, anis (*Pimpinella anisum*), caraway (*Carum carvi*), coriander (*Coriandrum sativum*), cumin (*Cuminum cyminum*), fennel (*Foeniculum vulgare*), are from the most exported Apiaceae medicinal seed plants addition to basil (*Ocimum basilicum*) and mint (*Mentha* spp.) as Lamiaceae medicinal leaf plants as well as chamomile (*Chamaemelum nobile*) as Asteraceae flower medicinal plant. All these plants produce many important essential oils according to their components such anethol, menthol, linalool, estragol, eugenol and chavicol as well as cumin aldehyde, cuminic alcohol and methyl cinnamate. Essential oil constituents are much used in medicine as a component of many drugs, very popular aromatherapy, antioxidants, antiseptic, antibiotics, antibacterials, antifungi and antiviruses [2-10].

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In field, the medicinal plants are economically damaged by many pests and diseases resulting in reduction of the crop productivity and deterioration in the yield quality. Furthermore, during the postharvest processes especially in the storage, many destructive insect pests attacking the stored crops causing high rates of the loss quantitatively and qualitatively. The adults of these insects are flighting from infested packages, neglegted infested lots and/or from infested storage to another healthy [11, 12]. Abdelghany *et al.* [12] surveyed *Lasioderma serricorne*, *Stegobium paniceum*, *Tribolium castaneum*, *Tribolium confusum*, *Trogoderma granarium*, *Cryptolestes ferrugineus*, *Plodia interpunctella* and *Sitotroga cerealella* on six medicinal plants at two Egyptian warehouses in Mansoura and Bilqas.

Therefore, the aim of this study was to estimate the insect pest infestation and the resulting losses in eight medicinal plants collected from two bio-products companies: Sekem Company (SC) and Royal Company (RC) in Egypt.

MATERIALS AND METHODS

The Plant Materials: Seeds of five medicinal plants: anise *Pimpinella anisum*, caraway *Carum carvi*, coriander *Coriandrum sativum*, cumin *Cuminum cyminum* and funnel *Foeniculum vulgare* each belongs to the family Apiaceae, addition to dried leaves of two plants basil *Ocimum basilicum* and ment *Mentha virids* those belong to the family Lamiaceae as well as flowers of chamomile plant (*Chamaemelum nobile*) which belongs to the family Asteraceae were collected to be the plant materials of this study. The plant samples were obtained one-month post harvest from the stores of both Sekem Company (SC) that located in Belbeis, Sharkia governorate and Royal Company (RC) that located in Shabramant, Giza Governorate in Egypt.

Estimating the Infestation Density of Insect Pests: The collected plant samples were stored for seven months from Jun to December 2012 under room temperature in the laboratory. This storage period may be similar with the duration that the products take up in the company's stores until exporting. The weight of sample was 5 kg / plant divided into three groups for each plant. The first group (G1) was incubated under room temperature without any treatments to monitor the population of insect pests. The second group (G2) was maintained in modified atmospheres containing 80% CO_2 during seven months of the experiments to eliminate any insects may present in the samples and it is considered as control. The third group (G3) was left as stock culture to maintain insects for future experiments. The G1 and G2 had 3 replicates each (500 g per replicate). Plant material for each replicate was put into a jar covered with muslin and well bounded with rubber band. The Jars were stored at room temperature for the seven months. The jars were monthly examined for the presence of insect pests. The numbers of adults for each insect species per jar were counted and recorded to calculate the mean number of insects per month.

Estimating the Weight Loss of Plants: Corresponding to monthly examination of jars for the presence of insects in G1 and G2, plant materials were weighted to calculate the losses caused by insect infestation. The percentage of weight loss in leaves and flowers plants such as basil, mint and chamomile was calculated by the following equation:

$$\%\ \text{Weight loss} = \frac{\text{weight of healthy } plants - \text{weight of infested } plants}{\text{weight of healthy } plants} \times 100$$

Meanwhile, the percentage of weight loss in the seed plants such anise, fennel, cumin, caraway and coriander was calculated by the "count-and-weight" method described by Harris and Lindblad [13] applying the following equation

$$\%\ \text{Weight loss} = \frac{(Wu \times Nd) - (Wd \times Nu)}{Wu \times (Nd + Nu)} \times 100$$

Where, Wu means weight of undamaged seeds, Nd means number of damaged seeds, Wd means weight of damaged seeds and Nu means number of undamaged seeds.

Statistical Analysis: The obtained data were subjected to analysis of variance (ANOVA), with the means separated using Duncan's Multiple Range criterion ($P<0.05$) [14].

RESULTS

Natural Insect Infestation of Plants Obtained from Sekem Company and Their Losses

Anise: The plant was naturally infested by cigarette beetle *Lasioderma serricorne,* saw-toothed grain beetle *Oryzaephilus surinamensis* and the fennel wasp *Systole* sp. The latter was common and gradually increased during the storage period. The other two insects recoded very few numbers. Cigarette beetle recoded 0.3, 3.7 and 1 insect during July, November and December, respectively. The saw-toothed grain beetle appeared only on December

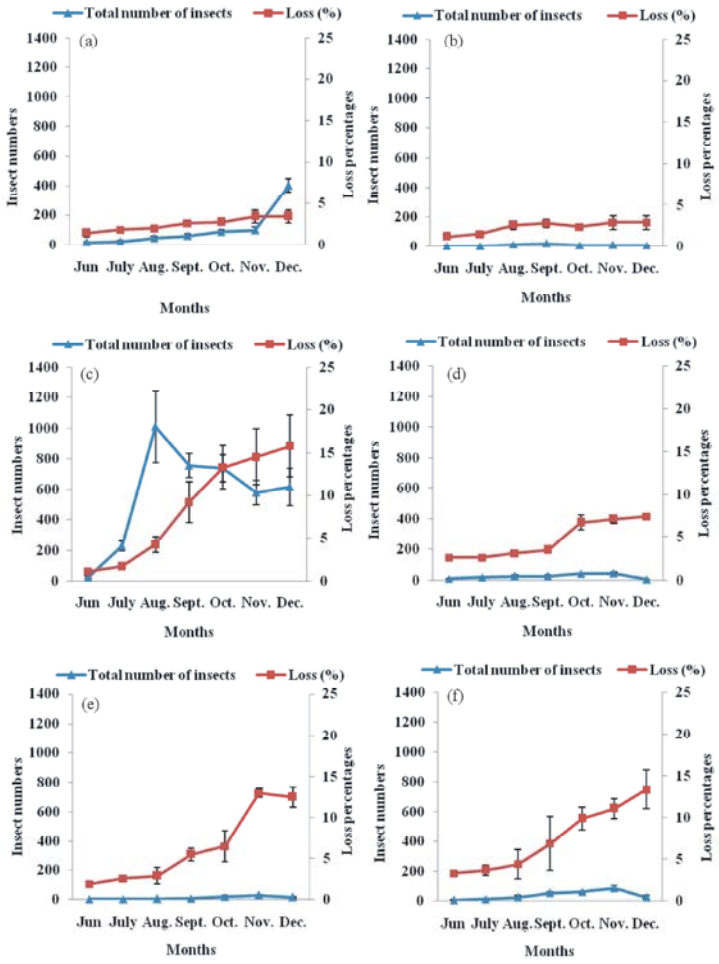

Fig. 1: Total number of insect pests on naturally infested medicinal plants obtained from Sekem Company (SC) and their losses during seven-month-storage period from Jun to December 2012. Anise (a), Mint (b), Chamomile (c), Basil (d), Cumin (e) and Coriander (f).

(18 insects). The highest population was recorded in December by *Systole* sp. (381 insects). The percentage of loss was ranged between 1.4 to 3.4% without significant differences between months (Table 1; Fig. 1a).

Mint: Three insects, *L. serricorne*, *O. surinamensis* and *Tribolium castaneum* were observed on mint. The first insect was recorded during November and December with numbers 8.7 and 4.3 insects, respectively. The second insect was monthly recorded with the range of 0.3- 9.7 insects. However, *T. castaneum* was recorded monthly with range of 0.3-9.3 insects (Table 1; Fig. 1b).

Chamomile: Chamomile was found to be more preferable for insects than anise and mint. The dominance insect pest of this plant was *L. serricorne* that recorded high numbers of insects with significant differences between populations through months. The insect number of this pest increased gradually from Jun (5.3. insects) to August (990.7 insects), then decreased gradually to record 564.3 insects in November and then increased again in December. It was also found *T. castaneum* and *O. surinamensis* those recorded lower insect numbers than *L. serricorne*. The insect numbers ranged between 1.7 - 16.0 and 2.3-16.0 insects in *T. castaneum* and *O. surinamensis*, respectively. A very few number of *Systole* sp was recorded in August and October (0.3 - 2.0 wasps). The total number of insects was significantly higher during August to October with peak 1011 insects recorded on August. The percentage of loss increased gradually during the storage period with significant differences among months. The loss began with 1.1% on Jun to end with 15.8% on December (Table 2; Fig. 1c).

Table 1: Population density of different insect pests on naturally infested medicinal plants (anise and mint) obtained from Sekem Company (SC) and their losses during seven-month-storage period from Jun to December 2012.

	Anise					Mint				
	Mean of insect number ±SE					Mean of insect number ±SE				
Month	*Lasioderma serricorne*	*Oryzaephilus surinamensis*	*Systole* sp	Total	Loss (%)	*Lasioderma serricorne*	*Tribolium castaneum*	*Oryzaephilus surinamensis*	Total	Loss %
Jun	0	0^{b}	$16.3±4.9^{b}$	$16.3±4.9^{c}$	1.4±0.4	0^{c}	$1.0±0.6^{bc}$	$0.3±0.3^{b}$	$1.3±0.3^{b}$	1.2±0.3
July	0.3±0.3	0^{b}	$21.3±5.8^{b}$	$21.7±6.1^{c}$	1.8±0.4	0^{c}	$1.3±1.3^{bc}$	$0.7±0.7^{b}$	$2.0±2.0^{b}$	1.5±0.2
August	0	0^{b}	$46.0±12.0^{b}$	$46.0±12.0^{bc}$	2.0±0.0	0^{c}	$6.0±3.5^{ab}$	$5.7±4.7^{ab}$	$11.7±8.0^{ab}$	2.6±0.5
September	0	0^{b}	$59.3±14.9^{b}$	$59.3±14.9^{bc}$	2.6±0.1	0^{c}	$9.3±1.2^{a}$	$9.7±2.3^{a}$	$19.0±1.2^{a}$	2.8±0.5
October	0	0^{b}	$87.3±17.4^{b}$	$87.3±17.4^{bc}$	2.7±0.0	0^{c}	$5.3±1.8^{abc}$	$2.7±1.2^{b}$	$8.0±1.0^{ab}$	2.4±0.2
November	3.7±2.3	0^{b}	$95.7±19.7^{b}$	$98.3±22.3^{b}$	3.4±0.8	$8.7±1.5^{a}$	$0.3±0.3^{c}$	$1±0.6^{b}$	$10.0±1.0^{ab}$	2.9±0.8
December	1.0±1.0	18^{a}	$381±54.6^{a}$	$400.3±46.0^{a}$	3.4±0.8	$4.3±3.0^{b}$	$07. ±0.7^{bc}$	$1.7±1.2^{b}$	$6.7±3.7^{b}$	2.9±0.8
F value	1.955	5.036	27.631	37.608	2.633	7.473	4.407	2.604	3.003	1.564
P value	IN	0.006	0.000	0.000	IN	0.001	0.010	0.050	0.042	IN

Means followed by different letters are significantly different from each other (Duncan test). IN = Insignificant

Table 2: Population density of different insect pests on naturally infested medicinal plants (chamomile and basil) obtained from Sekem Company (SC) and their losses during seven-month-storage period from Jun to December 2012.

	Chamomile						Basil				
	Mean of insect number ±SE						Mean of insect number ±SE				
Month	*Lasioderma serricorne*	*Tribolium castaneum*	*Oryzaephilus surinamensis*	*Systole* sp	Total	Loss %	*Lasioderma serricorne*	*Tribolium castaneum*	*Oryzaephilus surinamensis*	Total	Loss %
Jun	$5.3±0.9^{d}$	16.0±8.7	2.3±2.3	0	$23.7±5.8^{c}$	$1.1±0.2^{c}$	$6.0±2.1^{b}$	3.3±1.5	0	$9.3±3.3^{b}$	$2.6±0.1^{b}$
July	$217.0±31.8^{cd}$	2.0±2.0	8.7±4.9	0	$227.7±32.6^{c}$	$1.7±0.3^{c}$	$12.7±1.5^{b}$	7.3±6.8	0	$20.0±7.2^{b}$	$2.6±0.4^{b}$
August	$990.7±237.8^{a}$	5.7±4.7	15.0±9.6	0.3±0.3	$1011.7±235.3^{a}$	$4.2±0.9^{bc}$	$19.7±10.5^{b}$	6.3±6.3	0.3±0.3	$26.3±7.3^{ab}$	$3.1±0.3^{b}$
September	$734.0±87.8^{ab}$	9.3±6.2	11.3±11.3	0	$754.7±80.0^{ab}$	$9.2±2.4^{ab}$	$21.0±7.0^{b}$	4.3±3.4	0	$25.3±10.3^{ab}$	$3.5±0.1^{b}$
October	$721.7±97.6^{ab}$	1.7±0.9	12.0±7.2	2.0±1.5	$737.3±91.2^{ab}$	$13.3±2.6^{a}$	$41.3±3.5^{a}$	0.3±0.3	0.3±0.3	$42.0±4.0^{a}$	$6.7±0.9^{a}$
November	$564.3±75.9^{bc}$	3.7±3.2	9.7±5.0	0	$577.7±78.1^{b}$	$14.5±3.3^{a}$	$43.7±7.3^{a}$	0.3±0.3	0.3±0.3	$44.3±7.5^{a}$	$7.1±0.5^{a}$
December	$586.7±120.1^{bc}$	12.3±7.9	16.0±9.5	0	$615.0±121.5^{b}$	$15.8±3.6^{a}$	$4.7±0.9^{b}$	0	0	$4.7±0.9^{b}$	$7.4±0.2^{a}$
F value	8.184	0.989	0.344	1.591	8.549	7.334	7.505	0.636	0.667	5.288	25.101
P value	0.001	IN	IN	IN	0.000	0.001	0.001	IN	IN	0.005	0.000

Means followed by different letters are significantly different from each other (Duncan test). IN = Insignificant

Table 3: Population density of different insect pests on naturally infested medicinal plants (cumin and coriander) obtained from Sekem Company (SC) and their losses during seven-month-storage period from Jun to December 2012.

	Cumin						Coriander					
	Mean of insect number ±SE						Mean of insect number ±SE					
Month	*Lasioderma serricorne*	*Tribolium castaneum*	*Oryzaephilus surinamensis*	*Systole* sp	Total	Loss %	*Lasioderma serricorne*	*Tribolium castaneum*	*Oryzaephilus surinamensis*	*Systole* sp	Total	Loss %
Jun	2.0±1.5	0.3±0.3	0.7±0.3	$0.3±0.3^{d}$	$3.3±1.3^{d}$	$1.9±0.3^{d}$	$4.0±1.7^{c}$	0.3±0.3	0.3±0.3	0	$4.7±2.0^{c}$	$3.3±0.4^{d}$
July	0.3±0.3	0	0	$2.3±1.3^{d}$	$2.7±1.7^{d}$	$2.6±0.3^{cd}$	$10.0±2.6^{c}$	2.3±1.9	0	0.3±0.3	$12.7±1.2^{c}$	$3.7±0.6^{d}$
August	0.3±0.3	0.3±0.3	0	$3.7±0.3^{d}$	$4.3±0.3^{d}$	$2.9±1.0^{cd}$	$24.0±12.5^{bc}$	0	0	0.3±0.3	$24.3±12.2^{bc}$	$4.4±1.8^{cd}$
September	0.3±0.3	0	0.3±0.3	$7.7±2.0^{cd}$	$8.3±1.8^{cd}$	$5.5±0.8^{bc}$	$50.0±8.5^{ab}$	3.3±0.3	0	0.7±0.3	$51.7±8.5^{ab}$	$6.9±3.2^{bcd}$
October	0.3±0.3	0.3±0.3	0	$17.3±1.5^{b}$	$18.0±1.2^{b}$	$6.5±1.9^{b}$	$56.7±9.0^{ab}$	3.3±0.3	0.7±0.7	1.0±1.0	$58.7±8.6^{a}$	$9.9±1.4^{abc}$
November	0.3±0.3	0	0.3±0.3	$28.3±4.8^{a}$	$29.0±5.1^{a}$	$13.0±0.5^{a}$	$83.0±19.5^{a}$	0.7±0.3	0	0.3±0.3	$84.0±19.7^{a}$	$11.1±1.2^{ab}$
December	0	0	0	$13.7±2.6^{bc}$	$13.7±2.6^{bc}$	$12.5±1.2^{a}$	$23.3±11.3^{bc}$	0	0	0	$23.3±11.3^{bc}$	$13.4±2.3^{a}$
F value	1.064	0.667	1.44	18.353	15.449	20.697	6.872	1.181	0.867	0.615	7.006	4.926
P value	IN	IN	IN	0.000	0.000	0.000	0.001	IN	IN	IN	0.001	0.007

Means followed by different letters are significantly different from each other (Duncan test). IN = Insignificant

Basil: The main insect was *L. serricorne* with range of 6.0 - 43.7 insects during the storage period and its peak was on November. A few insect numbers were recorded for *T. castaneum* and *O. surinamensis*. The mean insect number of *T. castaneum* ranged between 0.3-7.3 insects, while *O. surinamensis* recorded lowest mean number (0.3 insects per month) on August, October and November. The total number of insect increased significantly from August to November with peak on November (44.3 insects). The loss % ranged between 2.6 - 7.4%, wherever, the significant highest loss was recorded on the last three months (Table 2; Fig. 1d).

Cumin: The main insect pest of cumin was *Systole* sp with mean ranging of insect number 0.3 to 28.3 wasps. The mean peak of wasp number was recorded on November. Cumin was also infested by *L. serricorne*, *T. castaneum* and *O. surinamensis* with very few insects for each. The mean ranging insect number was 0-2.0, 0-0.3 and 0-0.7 insects in *L. serricorne*, *T. castaneum* and *O. surinamensis*, respectively. The total number of insects increased gradually until reached to the peak on November and then declined. These insect numbers may have insignificant role in loss percentage that increased gradually from 1.9% on Jun to reach the peak on November 13.0% (Table 3; Fig. 1e).

Coriander: Coriander seeds were infested by four insect pests, *L. serricorne*, *T. castaneum O. surinamensis* and *Systole* sp. The first insect was the most dominant with

mean insect numbers ranging from 4.0 to 83.0 insects. The population of this insect increased significantly through storage period and reached to the peak on November. A few insect numbers were recorded in *T. castaneum* (0.0-3.3 insects), *Systole* sp (0.0-1.0 insect) and *O. surinamensis* (0.0 - 0.7 insect). The total insect number increased gradually until reached to the high population on November and then declined. Also the loss% corresponding to the total insect number increased gradually with significant differences among months. The highest value of loss (13.4%) was recorded on December (Table 3; Fig. 1f).

Natural Insect Infestation of Medicinal Plants Obtained from Royal Company and Their Losses

Anise: Anise seeds obtained from Royal Company (RC) were subjected for insect pests' investigation. They was infested by the same insects those infested anise obtained from SC, while *T. castaneum* was found on anise seeds obtained from RC farm but it was absent on anise obtained from SC. *Systole* sp was the main insect pest with mean insect number ranged from 4.0 to 37.7 wasps. Low population ranged 0.0 - 3.0, 0.0 - 1.7 and 0.0 - 1.7 insects for *L. serricorne*, *T. castaneum* and *O. surinamensis*, respectively were also recorded. The total number of insects per month increased gradually with two peaks on September and December causing losses ranged from 1.3 - 4.4% (Table 4; Fig. 2a).

Mint: Mint presented highly resistance to insect infestation. It was infested by a few insect numbers of *L. serricorne* and *Systole* sp. The first insect was found on October only with mean number 2.3 insects. The fennel wasp was recorded on September and October with mean number 9.0 and 29.0 insects, respectively. The loss percentage was 0.9% on Jun and increased gradually to reach the peak on October (4.7%) and then declined to reach 3.6% on December (Table 4; Fig. 2b).

Caraway: Caraway was infested only by *Systole* sp with mean insect number ranged from 5.3 to 35.3 insects. The significant high mean numbers were recorded on the last four months causing significant percentage of loss. The loss % increased gradually from 0.4% to reach the peak 3.0% on the latest Month (Table 4; Fig. 2c).

Table 4: Population density of different insect pests on naturally infested medicinal plants (anise, mint and caraway) obtained from Royal Company (RC) and their losses during seven-month-storage period from Jun to December 2012.

	Anise						Mint				Caraway	
	Mean of insect number ±SE						Mean of insect number ±SE				Mean of insect number ±SE	
Month	*Lasioderma serricorne*	*Tribolium castaneum*	*Oryzaephilus surinamensis*	*Systole* sp	Total	Loss %	*Lasioderma serricorne*	*Systole* sp	Total	Loss %	*Systole* sp	Loss %
Jun	0	0.3±0.3	0	4.0±2.1^{c}	4.3±1.9^{d}	1.3±0.1^{b}	0	0^{b}	0^{b}	0.9±0.1	0^{b}	0^{c}
July	1.7±1.7	1.3±1.3	0	5.7±0.9^{c}	8.7±0.9^{cd}	1.6±0.1^{b}	0	0^{b}	0^{b}	1.6±0.4	5.3±2.3^{b}	0.4±0.2^{c}
August	0	0.3±0.3	0	10.7±3.7^{bc}	11.0±3.6^{bcd}	1.9±0.4^{b}	0	0^{b}	0^{b}	2.7±0.2	6.3±3.3^{b}	0.8±0.5^{bc}
September	3.0±3.0	0	1.3±0.9	18.7±3.3^{b}	23.0±3.0^{b}	3.2±0.2^{b}	0	9.0±7.1^{b}	9.0±7.1^{b}	4.0±0.8	17.3±9.6^{ab}	2.0±1.0^{ab}
October	0.7±0.3	1.3±1.3	1.7±1.7	16.0±3.5^{bc}	19.7±5.0^{bc}	3.8±0.7^{a}	2.3±1.5	29.0±2.6^{a}	31.3±2.2^{a}	4.7±0.0	27.7±7.1^{a}	2.5±0.5^{a}
November	1.0±1.0	1.7±1.2	0	18.3±4.6^{b}	21.0±5.5^{bc}	3.9±0.6^{a}	0	0^{b}	0^{b}	3.6±1.8	30.0±7.2^{a}	2.8±0.2^{a}
December	0	0	0.3±0.3	37.7±5.9^{a}	38.0±6.2^{a}	4.4±0.6^{a}	0	0^{b}	0^{b}	3.6±1.8	35.3±8.2^{a}	3.0±0.2^{a}
F value	0.678	0.667	0.980	9.040	7.324	8.433	2.579	14.564	17.579	1.844	4.885	5.844
P value	IN	IN	IN	0.000	0.001	0.001	IN	0.000	0.000	IN	0.007	0.003

Means followed by different letters are significantly different from each other (Duncan test). IN = Insignificant

Table 5: Population density of different insect pests on naturally infested medicinal plants (chamomile, basil and fennel) obtained from Royal Company (RC) and their losses during seven-month-storage period from Jun to December 2012.

	Chamomile					Basil					Fennel	
	Mean of insect number ±SE					Mean of insect number ±SE					Mean of insect number ±SE	
Month	*Lasioderma serricorne*	*Tribolium castaneum*	*Oryzaephilus surinamensis*	Total	Loss %	*Lasioderma serricorne*	*Tribolium castaneum*	*Oryzaephilus surinamensis*	Total	Loss %	*Systole* sp	Loss %
Jun	0.3±0.3	0.3±0.3	0.3±0.3	1.0±0.6^{b}	0.8±0.3^{c}	2.7±1.2^{c}	0.3±0.3	1.7±1.2	4.7±2.2^{b}	0.3±0.0^{d}	29.3±14.8^{c}	1.0±0.1^{c}
July	2.0±0.6	2.0±2.0	0.3±0.3	4.3±1.5^{b}	0.9±0.3^{bc}	0^{c}	1.7±1.2	3.3±2.4	5.0±1.5^{b}	0.9±0.2^{cd}	43.3±8.4^{bc}	1.2±0.5^{c}
August	5.3±0.9	2.0±2.0	0.7±0.3	8.0±2.5^{b}	1.5±0.1^{abc}	6.3±6.3^{bc}	3.7±2.0	3.3±2.3	13.3±3.5^{ab}	1.6±0.2^{bc}	41.3±6.4^{bc}	2.4±0.1^{bc}
September	6.3±1.8	2.0±1.5	0.3±0.3	8.7±2.4^{b}	1.9±0.5^{ab}	26.7±13.6^{abc}	1.0±1.0	2.3±2.3	30.0±15.5^{ab}	2.4±0.5^{ab}	50.3±12.3^{bc}	3.3±0.4^{abc}
October	4.7±0.9	4.3±1.2	1.0±0.6	10.0±2.1^{b}	1.8±0.2^{ab}	35.0±15.5^{ab}	1.7±1.7	2.3±1.2	39.0±13.1^{a}	2.9±0.3^{a}	75.0±3.5^{ab}	4.5±0.4^{ab}
November	3.7±1.8	3.3±2.4	1.7±1.7	8.7±2.8^{b}	2.0±0.3^{a}	34.3±8.2^{ab}	2.0±2.0	4.0±2.3	40.3±7.5^{a}	3.0±0.5^{a}	73.0±9.8^{ab}	5.1±1.5^{ab}
December	7.7±3.2	11.0±10.5	2.3±1.9	20.0±6.5^{a}	2.0±0.3^{a}	36.3±3.7^{a}	2.7±1.2	0.3±0.3	39.3±4.3^{a}	3.3±0.5^{a}	94.0±17.0^{a}	5.4±1.4^{a}
F value	2.048	0.672	0.608	3.504	2.910	3.462	0.555	0.424	3.713	9.266	4.215	4.507
P value	IN	IN	IN	0.025	0.047	0.026	IN	IN	0.020	0.000	0.012	0.010

Means followed by different letters are significantly different from each other (Duncan test). IN = Insignificant

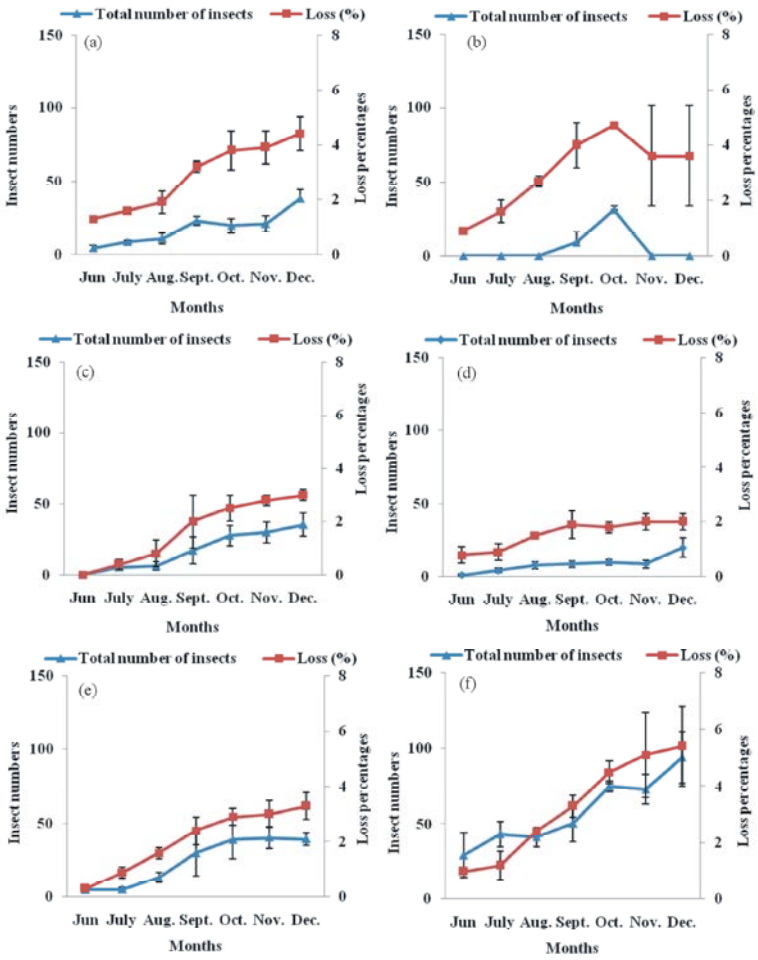

Fig. 2: Total number of insect pests on naturally infested medicinal plants obtained from Royal Company (RC) and their losses during seven-month-storage period from Jun to December 2012. Anise (a), Mint (b), Caraway (c), Chamomile (d), Basil (e), and Fennel (f).

Chamomile: Chamomile was infested by *L. serricorne*, *T. castaneum* and *O. surinamensis* like those observed in SC. Consequently the losses corresponding were lower than those recorded in SC. The mean insect number was ranged 0.3 - 7.7, 0.3 - 11.0 and 0.3 - 2.3 insects of *L. serricorne*, *T. castaneum* and *O. surinamensis*, respectively. The total insect number increased gradually until to reach the peak (20.0 insects) on December. The corresponding losses increased gradually from 0.8 to 2.0% (Table 5; Fig. 2d).

Basil: *L. serricorne* was the main insect found on basil beside individuals of *T. castaneum* and *O. surinamensis* like the basil obtained from SC. The range of insect mean number was 0.0 - 36.3, 0.3 - 2.7 and 0.3 - 4.0 insects, in *L. serricorne*, *T. castaneum* and *O. surinamensis*, respectively. The total of insect number ranged between 4.7 to 40.3 insects with corresponding losses ranged between o.3 - 3.3%. The last four months exhibited high significant insect population and losses (Table 5; Fig. 2e).

Fennel: Only the fennel wasp *Systole* sp was found on fennel with mean wasp number ranged from 29.3 to 94 wasps. The wasp caused losses ranged from 1.0 to 5.4 %. Both mean number of wasps and mean loss% increased gradually until they reached to the peak on the last month (Table 5; Fig. 2f).

DISCUSSION

Recently, organic culture occupies special attention from bio-products companies that deal with crops that exported to abroad. This trend is considered go back to the nature where there is no insecticide causes drastic problems on human health and environment. Also, there is a customer who prefers an organic product that grown

far from exposure of any chemicals. In Egypt, some companies such Sekem Company (SC) and Royal Company (RC) produce medicinal plants for international markets as bio products. These companies sow medicinal plants under organic culture and store the products in their storages for a period may extend five to seven months before exporting abroad. Therefore, eight medicinal plants were collected one-month post harvest from SC and RC and stored for seven months under room temperature to estimate the infestation of insect pests and their losses. Plant samples were monthly investigated during the period from Jun to December 2012.

This study revealed that all investigated medicinal plants were infested by one or more insect pests. The total number of insects and their losses differed from plant to another. Four insect pests; *Lasioderma serricorne, Tribolium castaneum*, *Oryzaephilus surinamensis* and *Systole* sp were found on plants collected from both SC and RC. Some plants exhibited low losses such as anise, basil collected from both SC and RC, as well as fennel and chamomile at RC only. This may due to these plants may not suitable for insect feeding to increase their numbers or the initial infestation was low. In spite of some medicinal plants were used in controlling many insects, it was found that some plants were susceptible to insects and recorded high losses. Moreover, the total number of insects increased gradually from the first month to reach the peak that differed from plant to another. Consequently, the loss rates increased gradually to reach the maximum corresponding to the highest total number of insects. However, in chamomile collected from SC in spite of the total insect numbers was significantly higher on August to October, but the highest loss % was recorded at the last month. This may attribute to the immature stages of the next generations those multiplied from the adult of these high insect numbers.

There was a single previous publication conducted in two different sites located north Cairo (in Mansoura and Bilqas) surveyed insect pests on six stored botanicals. These plant products included anise, coriander and chamomile but this study did not estimate the losses [12]. They found *L. serricorne* as the common insect pest in warehouses and *T. castaneum* that had lower infestation. They also added other insect pests were not found in this study such as *Stegobium paniceum*, *Tribolium* confusum, *Trogoderma granarium, Cryptolestes ferrugineus*, *Plodia interpunctella* and *Sitotroga cerealella*.

The cigarette beetle *L. serricorne* was found on all tested medicinal plants except caraway and fennel. However Kant *et al*. [15] found *L. serricorne* on fennel and it caused huge storage losses in fennel seed (58.02%). *Lasioderma serricorne* was also recorded on ginger and coriander [16, 17]. In the present study, this insect appeared in November and December recording few numbers ranged between 1.0 - 8.7 insects on anise and mint at Sc. In RC, it was found in July, September, October and November on anise and in October only on mint recording number ranged between 1.0 - 3.0 insects. Therefore, it is thought that this insect did not have significant role on losses on anise and mint at SC and RC. This deduction was observed also on cumin at SC. Meanwhile, it was considered the main insect pest on chamomile, basil and coriander at SC. It caused high losses on these plants reached up to 15.8%, 7.4% and 13.4%, respectively. Additionally, *L. serricorne* shared *T. castaneum* and *O. surinamensis* in losses recorded on chamomile and basil at RC.

This study is firstly considered in monitory the saw-toothed grain beetle *O. surinamensis* on medicinal plants. *Oryzaephilus surinamensis* was found on all investigated plants (excepting mint, caraway and fennel collected from RC). It revealed lower level of infestation than *L. serricorne*. It recorded very few insect numbers on anise, basil, cumin and coriander at SC and on anise, chamomile at RC. So, it may not have a role in losses recorded in these plants. It recorded a moderate insect numbers on mint, chamomile at SC and basil at RC. Wherever, it shared *T. castaneum* to give losses up to 2.9% on mint at SC. It also shared both *L. serricorne* and *T. castaneum* to cause losses reached up to 15.8% and 3.3% on chamomile at SC and basil at RC, respectively.

Also, this study is firstly considered that clarify the economic importance of the fennel wasp *Systole* sp. on medicinal plants. *Systole* sp. was found on anise, chamomile at SC and RC, on cumin and coriander at SC and on mint, caraway and fennel at RC. *Systole* sp. revealed a few numbers on chamomile and coriander at SC and on mint at RC. Therefore, it may have a role in losses recorded in these plants. Moreover, it is considered the main insect pest on anise, chamomile and cumin at SC causing loss ranges 1.4 - 3.4%, 1.1 - 15.8% and 1.9 - 13.0%, respectively. It was also observed that *Systole* sp. was the main insect pest on anise, caraway and fennel at RC recording loss ranges 1.3 - 4.4%, 0.4 - 3.0% and 1.0 - 5.4%, respectively. It was a single insect pest that was found on fennel and caraway.

The flour beetle *T. castaneum* was found on mint, chamomile, basil, cumin and coriander at SC and on anise, chamomile and basil at RC. It recorded very few insect numbers on cumin and coriander at SC and on anise at RC. These low insect numbers may not have any role in losses recorded on these plants. *Tribolium castaneum*

revealed moderate insect numbers on mint, chamomile, basil at SC and on chamomile and basil at RC. Then, these moderate numbers may have a limited role in losses recorded in these plants.

CONCLUSION

Losses due to *L. serricorne* were mainly recorded on basil, coriander, at SC, while it shared other insect pests to achieve losses in other plants. *Systole* sp. was the main insect pest caused losses on anise and cumin at RC. Also, it was a unique insect responsible for losses recorded on caraway and fennel at RC. *Systole* sp. shared other insects to give losses on chamomile at SC. *T. castaneum* and *O. surinamensis* could cause losses together or with other insects on all investigated plants.

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