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New unit for mass - production of *Sitotroga cerealella* (Olivier) eggs for rearing the parasitoid *Trichogramma* used in insect pest control

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ABSTRACT

The presented study aimed to follow the biology of the angoumois grain moth, *Sitotroga cerealella* (Olivier) after rearing on wheat grains in two rearing units (classical and new) in order to verify which is better for mass – production of *Sitotroga* eggs used , subsequently for mass - production of *Trichogramma* to be used in insect pests control. The new unit may be considered a new idea for improving the mass-production of *Sitotroga* eggs. The ovipositional period and the larval, pre- pupal and pupal periods of *Sitotroga cerealella* lasted (3.60±0.24& 3.40±0.40), (17.4±0.17 & 17.4±0.22), (3.40±0.24 & 3.80±0.20) and (5.20±0.20 & 5.00±0.00) days for eggs and subsequent immature stages from the classical and new units, respectively. Hatching percentages among *Sitotroga cerealella* eggs were 95.57±0.61 and 96.55±0.62, respectively being nonsignificntly, different. Concerning the ovipositional periods, durations of life stages and hatching percentages among the obtained eggs, those also varied nonsignificantly. From another point of view, the new unit had many advantages than the classical one, such as; a - easier handling with the wheat grains used for mass- rearing and *Sitotroga* eggs added to these grains, b - durability of the new unit than the old one making it less expensive ., c - easier to be manufactured from different metals. and d – saving time in applying the steps of mass production of *Sitotroga* eggs , so saving time and effort; e - The number of eggs for females from the new rearing unit was , significantly 307.00 opposed to 257.40 eggs / female from the classical one, indicating 19.46 % increase by rearing in the new unit .

Key words: *Sitotroga cerealella*, Rearing units , *Trichogramma ,* Classical rearing unit , New rearing unit .

Introduction

Sitotroga cerealella (Olivier) (Lepidoptera : Gelechiidae) attacks all types of cereal grains, particularly wheat where weight losses can be as much as 50% (Athanassiou *et al*., 2005).. Heavily infested grains have a sickening smell and taste that makes it unpalatable. This leads to considerable quantitative and qualitative economic losses represented in weight loss, decrease of nutritional value of wheat and reduction of germination .Infestation to wheat grains starts in the field and continues in the store (Muthukumar *et al*., 2016). Germination of infested wheat grains decreases with the increase of insect infestation (Anand and Jagadiswari, 1986). Although of the seriousness of *Sitotroga cerealella* in damaging grains of cereals in the field and the store, eggs of this insect pest are very important all over the world for mass – production of *Trichogramma* parasitized eggs. This may be attributed, mainly, to easy mass rearing of *S. cerealella* in the laboratory. The present study was carried out hoping to settle new modifications on the classical rearing unit for mass – production of *Sitotroga cerealella* eggs .

Materials and Methods

Eggs of *S. cerealella* used in this study were originally obtained from the Center of Production of Insect Predators and Parasitoids, Aswan Governorate during 2018. The obtained eggs were, subsequently, used for mass- production of *Sitotroga* eggs to be used for the mass – production of parasitized eggs by *Trichogramma* as follows:

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The insects were cultured in a rearing room of the Insect Research Laboratory at the Plant Protection Department, Fac. of Agric. at Moshtohor, Benha University. This rearing room was maintained at 27±1ºC and 65 ± 5% R.H.

Classical method for rearing Sitotroga cerealella and obtaining its eggs :

The eggs of *S. cerealella* were distributed on wheat grains in special alumital double surface trays under which a plastic jar was placed to collect the moths. Each tray hold 6 kg. wheat grains on which 6 gm. of *Sitotroga* eggs added .

The following was the method of preparation of wheat:

1- Wheat was washed for removing dust and other strange materials and boiled for 2 minutes and then filtered from water.
2- Wheat grains were spread on a table to make a thin layer in a clean place and left until dryness (Fig.1; 1).
3- The wheat was packed in the trays (6 kg. / trays) and placed in a horizontal position . Eggs of the grain moth were distributed at a rate of 1 g. grain moth eggs /1 kg. wheat grains (Fig. 1 ; 2).
4- Frames were placed in horizontal position leaving spaces between them to allow ventilation so as not to rot wheat grains (Fig. 1; 3).
5- After 10 days, each frame was lifted and adjusted vertically in the designated compartment inside the cage (Fig. 1; 4 & 5).
6- The unit was well closed and kept under close observation until emergence and falling moths , in the plastic jar placed under trays (Fig. 1 ; 6).
7- The plastic jar was changed daily and the resultant moths were emptied into special cylinders coated with a wire screen with fine pores that allow the eggs to pass through and prevent the moths to escape out.

Fig. 1: Classical *Sitotroga cerealella* rearing cage ; steps to lay the eggs on wheat grains .

The new S. cerealella rearing unit:

Egg of *S. cerealella* were distributed on wheat grains in special cages made of galvanized sheets (Fig. 2 ; 4) :

1- A cubic base of iron (60 x 40 cm) and a height of 70 cm (Fig. 2 ; 1)
2- Rectangular metal cages measuring 60 x 40 cm and 20 cm height with narrow wire screan base to be fixed of previously mentioned base , leaving 10 cm from each side to allow the emerged *Sitotroga* moth to fall down in the lower empty base (Fig. 2; 2).

This unit can be replicated to hold higher amounts of wheat grains and can be manufactured with different dimensions and different materials, whatever available.

3-Each cage is covered with a metal sheet leaving in the middle 40 x 20 cm opening filled with narrow wire screen to allow ventilation and prevent escape of any *Sitotroga* moths (Fig. 2 ; 3) .

4-The dimensions of cages can be caged if needed.

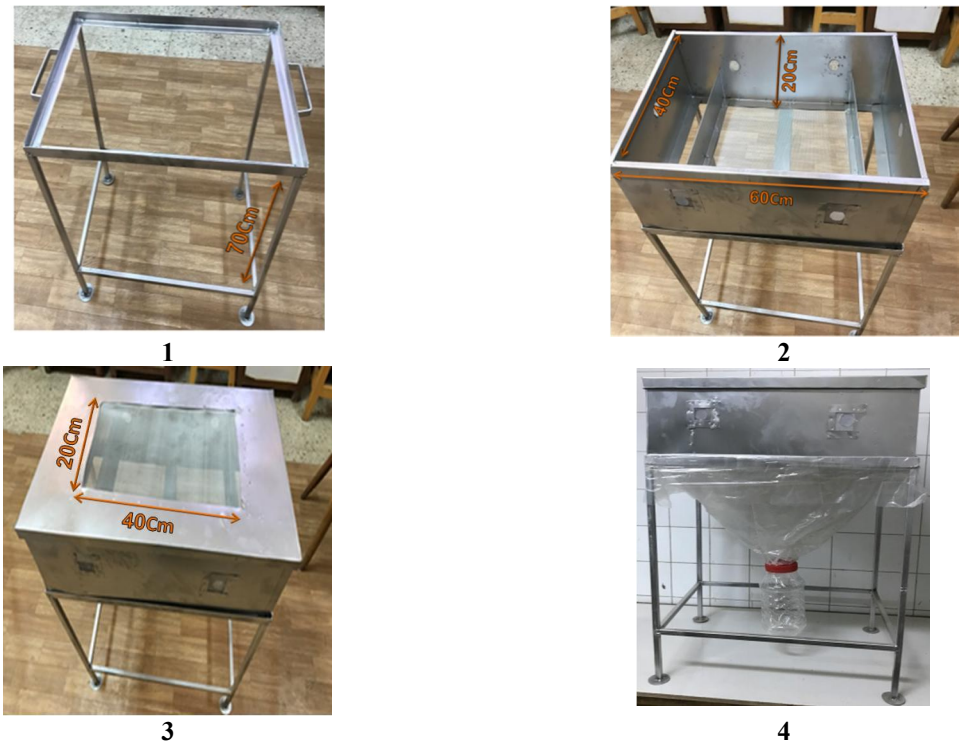

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Fig. 2: Detailed description of the installation of the new *S. cerealella* rearing unit.

It is worth mentioning to sign that this new *Sitotroga* mass – rearing cage is the first time to be described.

The following was the method of preparation of wheat:

1- Wheat was washed and boiled for 2 minutes and then filtered from water.
2- Separate the wheat in a thin layer in a clean place and left to dry.
3- The wheat was packed in trays (Fig . 3;1)
4- The eggs of the grain moth were distributed on wheat grains at the rate of *S. cerealella* eggs 1 g. grain moth eggs /1 kg. wheat. (Fig . 3;2)
5- Cages were closed well and kept under close observation until of moths emergence and orientation to the plastic jar (Fig. 3; 3, 4, and 5).
6- The plastic jar was changed daily and the resultant moths were emptied into special cylinders coated with a wire screen with fine pores that allow the eggs to pass through and prevent escape of any moths (Fig. 3;6) .

Eggs reproductivity / female:

Moth adults produced by rearing in each of the classical and new cages were allowed to deposit their eggs which were collected and weighed. The eggs reproductivity was subsequently calculated as the weight of eggs / female which was transferred to the number / female from each cage.

Hatching percentages:

A fixed number of *Sitotroga* eggs (about 1000 eggs) from either of the two rearing cages were glued on a paper sheet and kept under the laboratory conditions (27±1°C and 65±5 % R.H.) until hatching. Consequently the hatching % was calculated according to the following formula:

$$\% \text{ Hatching} = \frac{\text{No. of hatched eggs}}{\text{Total no. of eggs}} \text{ X } 100$$

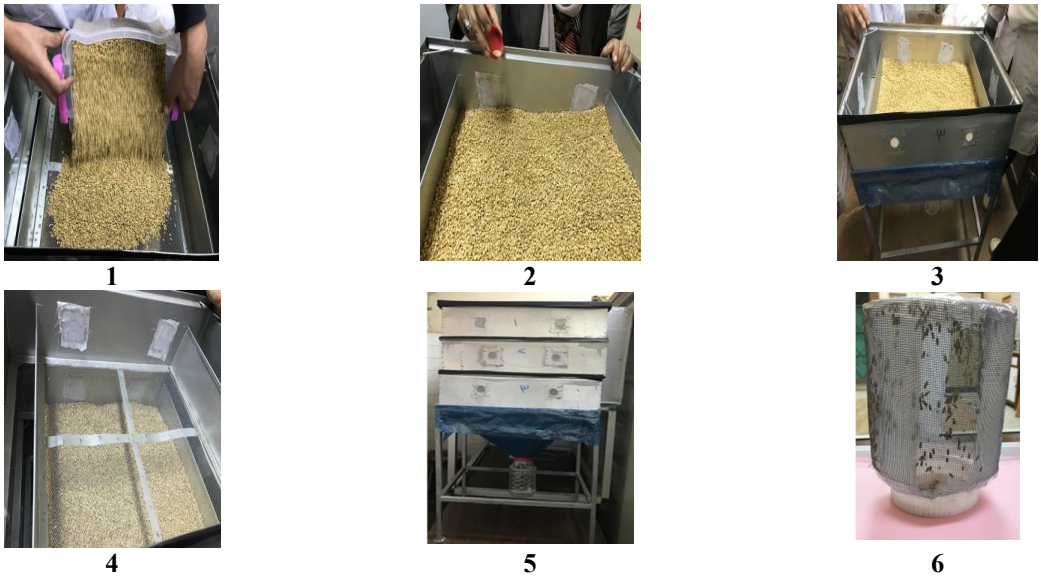

Fig. 3: New unit for rearing and mass – production of *S. cerealella* eggs.

Statistical analysis

All data were analyzed using ANOVA with three factors at 0.05 significance level for the whole results using SPSS (ver. 22). Data were treated as complete randomization design according to Steel *et al*. (1997). Multiple comparisons of significance were carried out applying LSD values .

Results and Discussion

Comparison between classical and new unit:

1-The Ovipositional periods and total deposited eggs/ female:

Preoviposition period:

The preoviposition period lasted 2.00 ± 0.20 and 1.99 ± 0.32 days at 27 ± 1°C and 65 ± 5% RH. for females from the classical and new units , respectively (table 1). Nonsignificant difference was detected between any means of preoviposition period between the two methods.

Oviposition period:

The oviposition period occupied 3.60 ± 0.24 and 3.40 ± 0.40 days at 27 ± 1°C and 65 ± 5% RH. for females from the classical and new methods , respectively (table 1) The eggs were laid singly or in small groups of 4 -7 eggs (fig. 4) . In similar studies, Hansen *et al.* (2004) observed that a *S. cerealella* female laid 120-350 eggs on paddy grains and other cereals and also on depressions, cracks, crevices and holes of the storage structures. Non-significant difference was detected between the means of oviposition period by two methods.

Postoviposition period:

The postoviposition period lasted 2.00 ± 0.32 days for moth females from the classical unit and 2.20 ± 0.37 days for those of the new unit at 27 ± 1°C and 65 ± 5% RH .The difference was detected between the two Postoviposition periods was statistically , nonsignificant .

Fig. 4: Eggs of *S. cerealella* on a wheat grains (5x)

Eggs reproductivily / female:

As shown in table (1), the mean total number of *S. cerealella* eggs produced / female from rearing in the new unit was 307.00 ± 13.28 eggs being , statistically , higher than the 257.40 ± 10.71 eggs / female from the classical rearing unit . Thus indicating 19.46 % increase by rearing in the former unit .Among the deposited eggs, the hatching percentage reached 96.55 ± 0.62 and 95.57 ± 0.61%, respectively with nonsignificant difference between the two values.

Table 1: Ovipositional periods and eggs reproductivity of *S. cerealella* moths under laboratory conditions of 27±1°C and 65±5 % R.H. by rearing in the classical and new units :

Rearing unit	Preoviposition	Oviposition	Postoviposition	Total eggs/female	No. of hatched eggs	% hatching
Classical	2.00±0.20^{A}	3.60±0.24^{A}	2.00±0.32^{A}	257.40±10.71^{A}	246.00±10.65^{A}	95.57±0.61^{A} 94 - 97.33
New	1.99±0.32^{A}	3.40±0.40^{A}	2.20±0.37^{A}	307.00±13.28^{B}	296.40±12.89^{B}	96.55±0.62A 94.04-98.39

A, B & C: There are nonsignificant differences (P>0.05) between any two means for the same attribute, within the same column having the same superscript letter.

Table 2: Developmental periods of different life stages of *S. cerealella* on wheat grains at 27±1°C and 65±5 % R.H.:

Developmental stage	Rearing unit	
	Classical	New
Total larval period	17.40±0.17 ^{A}	17.40±0.22 ^{A}
Pre-pupal	3.40±0.24^{A}	3.80±0.20^{A}
Pupal	5.20±0.20^{A}	5.00±0.00^{A}
Total developmental period	26.00±0.32^{A}	26.20±0.24^{A}
Male longevity	7.60±0.24^{A}	7.40±0.24^{A}
Female longevity	8.30±0.32^{A}	8.20±0.20^{A}

A, B & C: The difference (P>0.05) between any two means for the same attribute, within the same row having the same superscript letter is nonsignificant.

2-Larval development of *S. cerealella:*

The larvae developed through five instars. The newly hatched larvae were yellowish white in colour with light brown head (fig. 5). The total larval period duration lasted 17.40 ± 0.17 and 17.40 ± 0.22 days for larvae reared in the two units, respectively. After entering the grain, the larva often turns and closes the entry hole with a silken web. The larval life then begins in an environment of plenty of food and safety and continues in that state till being fully grown.

3-Prepupal and pupal periods:

The full - grown larva then cuts out a circular exit - hole leaving over it just a sort of cap (Anon, 2001). Full-grown larvae spin silken cocoons around each of them in hollows in the grain and become inactive (pre pupa, fig. 6) before pupation (Crombie, 1943). Pupa is brown coloured, develops inside

silken cocoon (fig. 7). Total of 3.40 ± 0.24 & 3.80 ± 0.20 days were required for prepupal stage, opposed to 5.20 ± 0.20 and 5.0 days for pupal stage under the laboratory conditions (Table 2). The present results agree with Akter *et al.* (2013) who stated that the prepupal and pupal periods lasted 3.0 and 5 days.

Fig. 5: Larvae of *S. cerealella* (5 x)

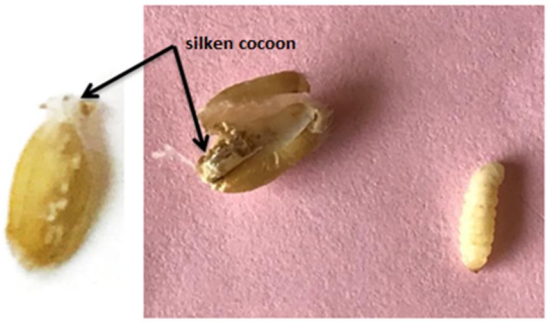

Fig. 6: Pre pupae of *S. cerealella* (5 x)

Fig. 7: Pupae of *S. cerealella* (5 x)

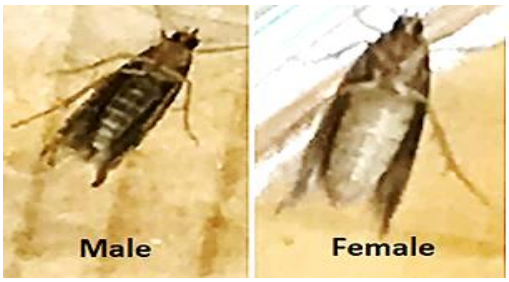

Fig. 8: Adult of *S. cerealella* (5 x)

4- Adult stage:

Adults of *S. cerealella* are good fliers, they are gray shin colour. Female moths are easily differentiated from males of which the abdomen is thinner, pointed and blackish from the ventral side, whereas in females the abdomen is bulky and long without any blackish coloration (fig. 8). Females lived, longer than males. The adult longevity was 7.60±0.24 & 7.40±0.24 days for males from the two rearing cages, respectively, opposed to 8.30±0.32 & 8.20±0.20 days for female (Table 2). In this respect, Akter *et al.* (2013) reported that the adult male longevity was 8 ± 0.13 days, while that of female was 10 ± 0.32 days.

In spite of the nonsignificant differences between all the biological measures of *S. cerealella* resulted from the two rearing units (classical and new), but the number of eggs for females was higher in the new rearing unit.

Also, the new unit confirmed reasonable advantages than the old one, these advantages are as follows:

1- Easier handling with the permanent cages insuring the possibility of increasing the number of cages ; i.e. , dealing with higher quantity of wheat grains , in addition to saving from any loss in wheat grains and / or the *Sitotroga* eggs added to these grains.
2- The new cages are more durable and less expensive than the old trays.
3- Capability of manufacturing the new cages from whatever available material.
4- Applying the needed steps for producing higher quantities of *Sitotroga* eggs within a much shorter period and with, approximated, no effort.

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