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Why the Mulberry Silkworms (*Bombyx mori*) are Monophagous and the Cotton Leaf Worms (*Spodoptera littorallis*) are Polyphagous?

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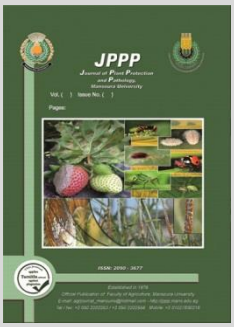

ABSTRACT

Larvae of order Lepidoptera have biting mouth parts and almost fed on leaves. The insects of Lepidopterous were divided into three groups depended on number of the host plants, the monophagous, the oligophagous and the polyphagous. Sense organs are responsible for the number of host plants and insects select for hosts to fed on. In this study, the head capsule of larvae was cut at the end of larval stage of the mulberry silkworms and the cotton leaf worms to examine by scanning electron microscope for the number and type of sense organs on head capsule of larvae of both insects. The total number of sense organs on the head capsule of the mulberry silkworm was 82 where they were more than that of the cotton leaf worm where they were only38 sense organs. In addition, When mouth parts of the mulberry silk worm were covered with nail polish then the larvae were offered five different species of plant leaves ,*Abelmoschus esculentus* (okra), *Vitis vinifera* (grapes), *Ricinus communis* (castor bean plant),*Cucurbita moschata* (Pumpkin) and *Morus alba* (mulberry) to fed on. The treated larvae couldn't recognize mulberry leaves to feed on. The larvae fed on small part of grapes and okra leaves then stopped to continue feeding. Vomiting and diarrhea were happened to larvae then died.

***Keywords*:** cotton leaf worm, mulberry silkworm, monophagous, polyphagous and sense organs.

INTRODUCTION

Monophagous insects fed on only one of host plant and can't fed on other hosts because they can know their host through sense organs distributed on the antennae or mouth parts or head capsule(Ishikawa and Hirao,1961, Hirao *et al.*1972, Hirao and Arai 1991, Kaissling 2009, Tanaka *et al.*, 2011 and Xu *et al.*2016).

When the sense organs increased in number in insects, these insects become monophagous insects such as mulberry silk worm (Tanaka *et al.*, 2011). On contrast, in the most insects, they have a lot of hosts and feed on more than two hosts and consider as polyphagous insects (Xu *et al.*, 2016) .This means that when the number of sense organs was less than monophagous insects, they become polyghagous such as cotton leaf worm.

The aim of this study to compare between amonophagous insect such as *Bombyx mori* and a polyphagous insect such as *Spodoptera littoralis* in number of sense organs distributed on mouth parts and head capsule by using scanning electron microscope and how can the monophagous insect feeds on other host plants.

MATERIALS AND METHODS

The monovoltine hybrid imported race of the mulberry silk worm was obtained from the Sericulture Research Department, Agricultural Research Centre, Ministry of Agriculture in form of eggs.

After rearing the larvae on mulberry leaves under standard rearing conditions (Krishnaswami, 1983) until reaching to the end of 5th instar, then larvae were collected to start the experimental laboratory.

The eggs of cotton leaf worm were obtained from Plant Protection Department, Agricultural Research Centre, Ministry of Agriculture and when eggs hatched, larvae reared on castor bean leaves. When they reached to the end of 6th instar larvae, they were collected to start the experimental laboratory.

Scanning electron microscope

To prepare the specimens for scanning, the head capsule of larvae of mulberry silk worm and cotton leaf worm were cut under the microscope. Head capsules were placed in Glutaraldehyde 3% for one hour and wash by buffer and then transferred to different concentrations of alcohol from 10% to100% for 10 minutes in each concentration. The head capsules were dried then fixed with double-stick tape on holder. Samples were gold coated by sputter coater .Three specimens of each species were photographed directly using the SEM video monitor (Jeojsm 5200) at Application Center for Insect Nematodes, Faculty of Agriculture, Cairo University. Sensilla were identified and compared.

Selection of the host

10 larvae of mulberry silk worm at5th instar larvae were collected and the head capsule surfaceswere covered by nail polish .Each treated larvae was introduced individually in separated box and offered five different leaves (*Abelmoschus esculentus* (okra), *Vitis vinifera* (grapes), *Ricinus communis* (castor bean plant), *Cucurbita moschata* (Pumpkin) and *Morus alba* (mulberry). All offered leaves were equal in size (square shape) and after one day the leaves were inspected and compared with control (10 normal larvae offered 5 leaves of mulberry (square shape) in the same previous size).Data was recorded.

RESULTS AND DISCUSSION

Numbers of sense organs on mouth parts and head capsule of *Bombyx mori* and *Spodoptera litorallis*

Table 1 showed the number of different sense organs on mouth parts and head capsule of mulberry silkworm and

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cotton leaf worm. The total number of sense organs was 82 sensilla in mulberry silkworm while they were 38 sensilla in cotton leaf worm.

Labrum: on dorsal surface of labrum, twelve tactile hairs were found in both mulberry silkworm and cotton leaf worm .In mulberry silkworm, the tactile hairs distributed on all the dorsal surface of labrum while, in cotton leaf worm they were found on the top of labrum (Fig. 1). On the ventral surface of labrum, many spines were occurred in regulation rows in both insects where they were short in cotton leaf worm (Fig. 3) while, were long, sharp and pointed in mulberry silkworm (Fig. 2).

Mandible: On dorsal surface of mandible 3 hairs on each were present in mulberry silkworm while, only 2 hairs were found on each mandible of cotton leaf worm (Fig 4).

Maxilla: On maxilla, one very longhair was found in mulberry silkworm while it was short in cotton leaf worm. As well as 5 hairs were found around the maxillary lobe in mulberry silkworm while, in cotton leaf worm only 4 hairs were found.

Labium: 2 hairs were occurred on mentum of mulberry silkworm and cotton leaf worm. In addition, 2 large basiconicum were only present on pre mentum of mulberry silkworm while they were decayed in cotton leaf worm (Fig. 5).

Antennae: 2 hairs were present as one short and the another long in both of them.

Clypeus: no sense organ was found.

Frons: 14 hairs were found in mulberry silkworm while, only4 hairs were occurred in cotton leaf worm.

Head Capsule: On dorsal view of head capsule,41 hairs were present in mulberry silkworm while, only 9 hairs were counted in cotton leaf worm (Fig.6).

Table 1. Numbers of sense organs on head capsule of *Bombyx mori* and *Spodoptera littoralis.*

Head capsule		*B. mori*		*S. littoralis*	
		No.	**Description**	**No.**	**Description**
Labrum	-Dorsal view -Ventral view	12	-Tactile hairs on allthe surface. -Long sharp and pointed spines in regulation rows	12	-Tactile hairs on top of labrum. -Short spines in regulation rows
Mandible	Dorsal view	3	Hairs on each	2	Hairs on each
Maxilla	-Stipes -Maxillary lobe	1 5	-Very long hair. -Hairs around it	1 4	-On the top and shorter than *B. mori* . - Hairs around it
Labium	-Mentum -Pre mentum	2 2	-Hairs -Large basiconicum	2 2	-Hairs -Decay
Antennae		2	short and long	2	short and long
Clypeus		-		-	
Frons		14	Hairs	4	Hairs
Head capsule	Dorsal view	41	Hairs are different in length	9	Hairs are different in length.
Total number		82		38	

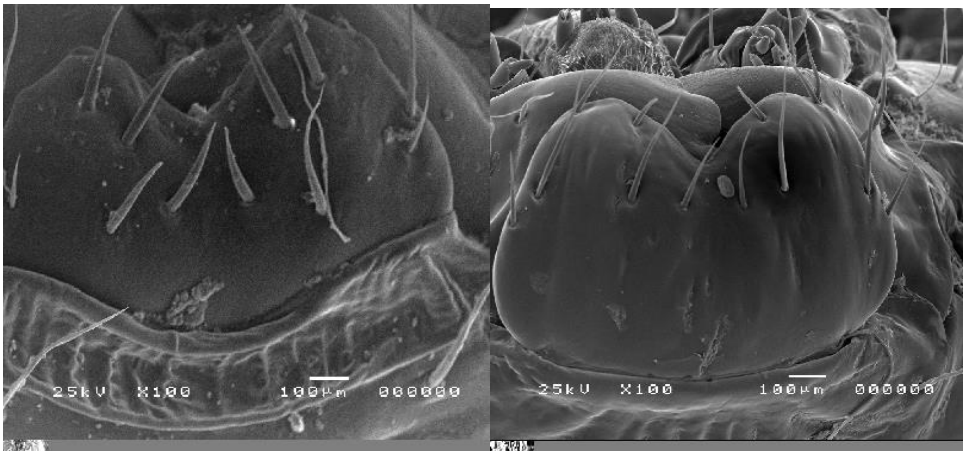


Fig.1. Tactical hairs on dorsal view of labrum of *B. mori* and *S. littoralis*

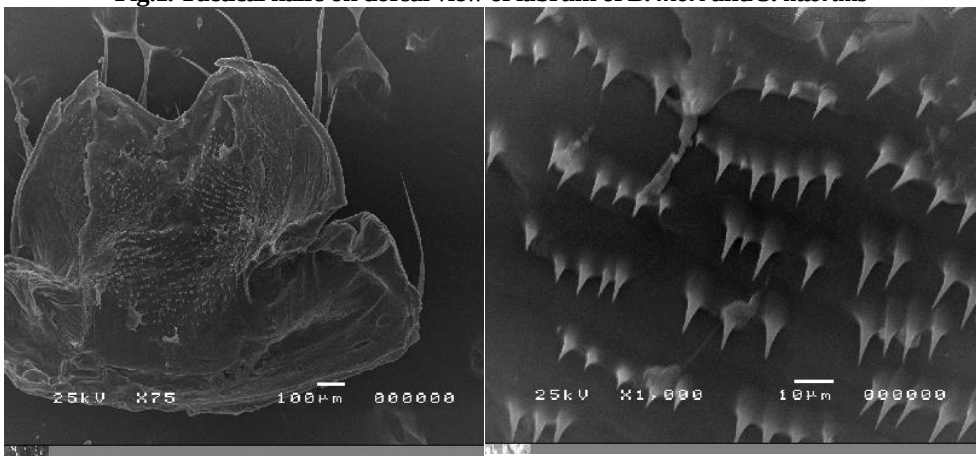


Fig.2. Long, sharp and pointed spines in regulation rows on ventral view of labrum of *B. mori*

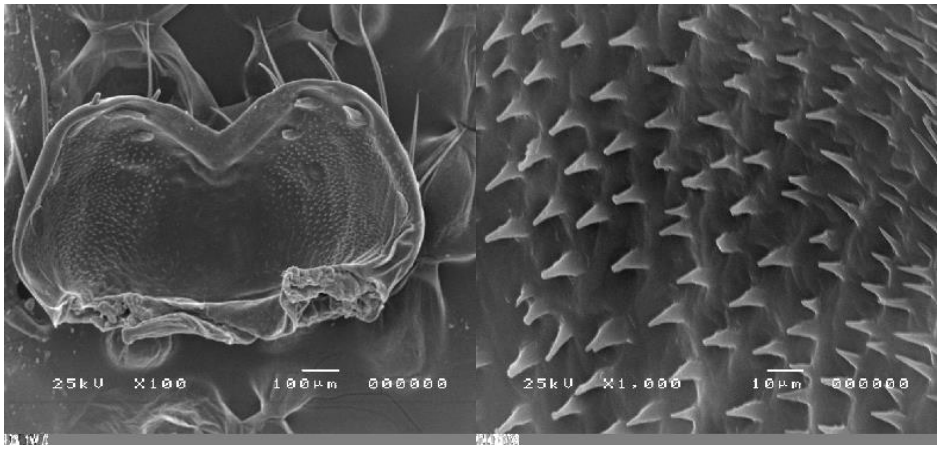


Fig.3. Short spines in regulation rows on ventral view of labrum of *S. littoralius*

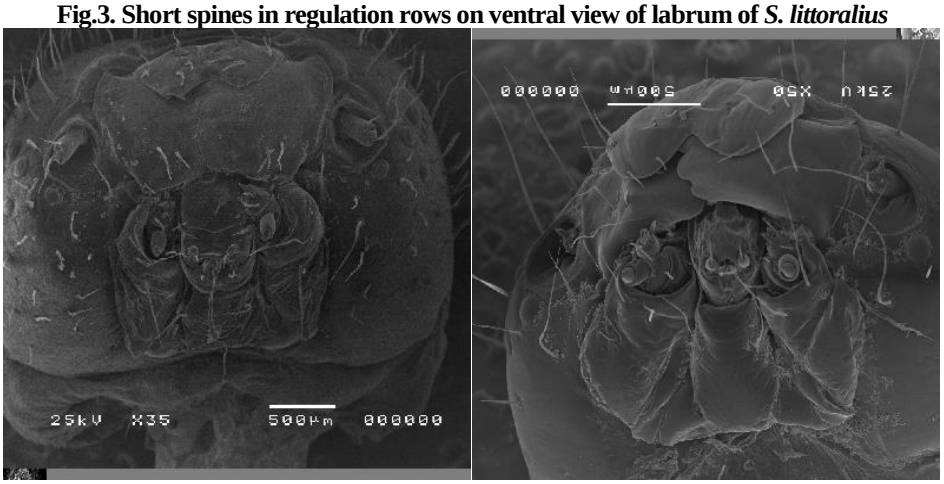


Fig.4. Tactical hairs on dorsal view of mandible and maxilla of *B. mori* and *S. littoralis*

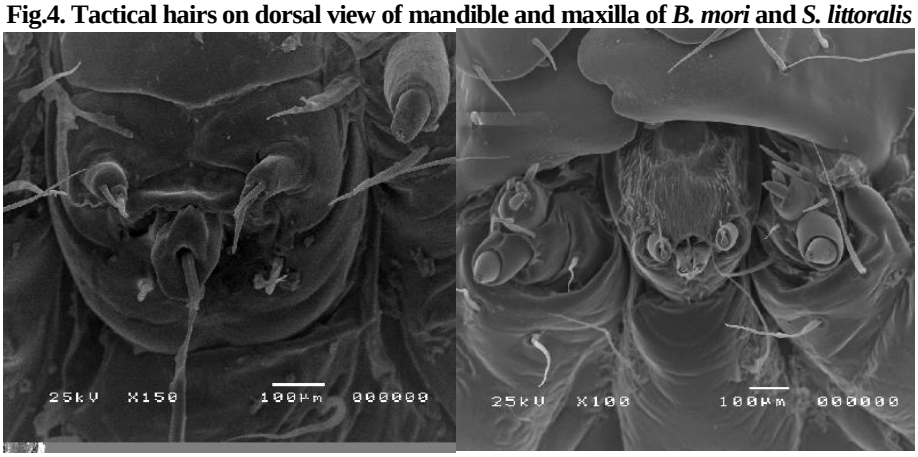


Fig.5. Tactical hairs and basiconicum on labium of *B. mori* and *S. littoralis*

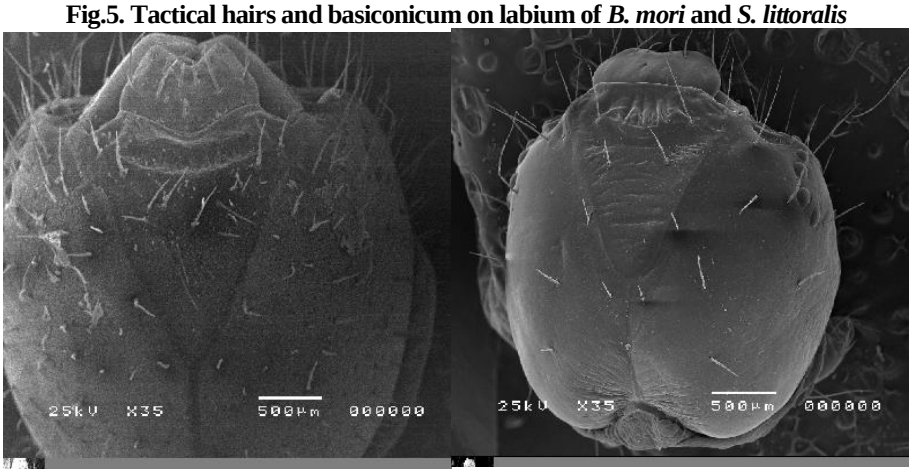
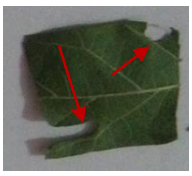


Fig.6. Tactical hairs on head capsule of *B. mori* and *S. littoralis*

Selection of the host:

As shown in Table 2,the mulberry silk worm larvae which their mouth parts were covered with nail polish then they were offered with five different leaves of *Abelmoschus esculentus* (okra) , *Vitis vinifera* (grapes), *Ricinus communis* (castor bean plant), *Cucurbita moschata* (Pumpkin) or *Morus alba* (mulberry)) for feeding .Eight treated larvae couldn't recognize mulberry leaves to feed on. Three larvae were fed on small parts of okra leaves and 4 larvae were fed on small parts of grape leaves then they stopped feeding. In addition, vomiting and diarrhea were happened to larvae then they died.

Table 2. Selection of the host by larvae of mulberry silkworm:

Type of leaves.	Okra	Grapes	Castor bean	Pumpkin	Mulberry
N0. larvae fed on leaves	3	4	---------	----------	2
Photo of leaves.					

The sense organs in all insects differ in their number and type (Gaaboub and Tousson, 2005, Faucheux, 2013, Abdelmegeed and Sawires, 2015 and Fleischer *et al.*, 2017). The distribution of sense organs on different body parts of insects such as on antennae, head capsule, mouth parts, legs and anal cerci was studied by Kent, *et al.*(1986), Hunger and Steinbrecht (1998), Pophof (1997), Dong *et al.*(2014) and Gaaboub *et al.*(2016).

The different sense organs on head capsule and mouth parts in larvae of mulberry silkworm were studied by Ishikawa and Hirao (1961), Hirao *et al*., (1972) and Kaissling (2009). They compared the number of sense organs on head capsule and mouth parts with those in larvae of cotton leaf worm where they found different in the number of sense organs. The results proved that the greater the number of sense organs in insects, the greater their sensitivity in selecting plant hosts such as mulberry silkworm (monophagous) (Hirao and Arai, 1991 and Tanaka *et al.*, 2011).The cotton leaf worm, has fewer sense organs than mulberry silkworm, thus, its sensitivity decreased in choosing the plant host and therefore it is polyphagous (Xu *et al.*, 2016).

Therefore, the number of sense organs affected directly the behavior of insects in general (Kaissling, *et al.*, 1978, Blaney and Simmonds, 1988 and Cao *et al.*, 2016). These behaviors are such as laying eggs (Gaaboub and Tousson, 2010 and Abdelmegeed, 2016), mating (Liu *et al.*,2013)and plant host selection in nutrition(Otter *et al.*,1978,Firempong and Zalucki,1989,Hirao and Arai,1991, Ziesmann *et al.*, 2000 and Krenn *et al.*, 2001)..

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لماذا دودة الحرير التوتية وحيدة العائل النباتي ودودة ورق القطن متعددة العوائل النباتية؟

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تتغذى معظم يرقات حرشفية الأجنحة ذات أجزاء الفم القارض على أوراق النبات. وتقسم حشرات حرشفية الأجنحة الي ثلاثة مجاميع تعتمد علي عدد العوائل النباتية، المجموعة الأولى وهي حشرات وحيدة العائل النباتي مثل دودة الحرير التوتية والمجموعة الثانية وهى محدود العوائل النباتية والمجموعة الثالثة هي حشرات متعددة العوائل النباتية مثل دودة ورق القطن.تعتبر أعضاء الحس هي العامل المحدد لاختيار عدد ونوع العوائل النباتية التى تتغذي عليها الحشرة.عند مقارنة عدد أعضاء الحس على علبة رأس كلا من حشرتي دودة الحرير التوتيه ودودة ورق القطن باستخدام الميكروسكوب الماسح وجد أن حشرة دودة الحرير التوتية التي تتغذي فقط علي أوراق التوت تحمل عدد كبير من أعضاء الحس على علبة الرأس وأجزاء الفم تصل الي 82 عضو حس وعند مقارنتها بدودة ورق القطن وجد أن علبة الرأس وأجزاء الفم تحمل 38 عضو حس علي أجزاء الفم وعلبة الرأس وذلك باستخدام الميكروسكوب الالكتروني.وفي دراسة أخرى عندما تمت تغطية أجزاء الفم وعلبة الرأس ليرقات دودة الحرير التوتية بطلاء الأظافر ثم تقديم خمس أنواع مختلفة من أوراق النباتات وهم كالآتي البامية والعنب والخروع والقرع والتوت لتغذيتها عليهم،وجد أن اليرقات المعاملة لم تستطيع التعرف على أوراق التوت لتتغذي عليها ولكن قامت بالتغذية على أجزاء صغيرة من أوراق البامية والعنب ولم تستمر في التغذية حيث توقفت عن التغذية وظهر قيء وإسهال ثم ماتت.مما يدل على أن أعضاء الحس الموجودة على علبة الرأس لها دور أساسي في التعرف على عائلها النباتي التي تتغذى عليه.