Oviposition Behavior of Pumpkin Fruit Fly, *Bactrocera depressus* (Tephritidae : Diptera) in a Cage Environment

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사육용기 환경 내에서 호박과실파리 산란행동

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ABSTRACT

The pumpkin fruit fly, *Bactrocera depressus* (Tephritidae: Diptera) is one of the most importance pests in Cucurbitaceae plants. This insect is known to attack various fruit vegetables for export and is considered a serious quarantine pest. Understanding the exact oviposition behavior of *B. depressus* is necessary to establish a bioassay protocols for screening oviposition stimulants or deterrents. The ovipositional sequence of *B. depressus* was observed in a rearing cage (42×30×35 cm) at 24 ± 1 ℃ with light intensity 2,000 Lux on the top and 800 Lux on the bottom in the cage. A green pumpkin was provided as oviposition substrate. The typical oviposition behavior showed a sequential steps : landing on the fruit surface and examining it with the proboscis or tarsi followed by expending-twisting-grooming of ovipositor; locating oviposition place after wandering and examining the fruit surface with the proboscis; drilling and egg deposition; and postovipositional behaviors such as expending-twisting-grooming of ovipositor and dragging of ovipositor on the fruit surface. Females displayed major two types of behavioral pattern, the full and reduced sequences. Most female (91.2%) showed the full sequence and some (8.8%) went directly to the step of locating oviposition place after landing.

Key Words : *Bactrocera depressus*, Pumpkin, Oviposition behavior, Grooming, Dragging

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INTRODUCTION

Fruit fly species belong to Tephritidae (called as Tephritid fly) have been known as an important pest in fruit vegetables and tree fruits throughout the world. In Korea, total 85 species of Tephritid fly in 45 genera are recorded (Han and Kwon, 2000). Among them, the pumpkin fruit fly, *Bactrocera depressus*, is one of the most importance pests in Cucurbitaceae plants. This insect is known to attack various fruit vegetables such as pumpkin, sweat pumpkin, ornamental pumpkin, gourd, water melon, melon and tomato (Han *et al.*, 1994), and is considered a serious quarantine pest in foreign countries.

The adult fly is approximately 10 mm in length with its wing length of 9 mm. The body color is light yellow. Distinctive characteristics of the adult is the dorsum of the thorax yellowish brown with three yellow stripes vertically. Also, the scutum color is yellow. The larva is a typical fly larva. It is cylindrical, tapering from a blunt posterior to a pointed head, and has no legs. The mature larva is creamy white except for two dark mouth hooks and is approximately 7 mm.

Bactrocera depressus has one life cycle a year in Korea. It overwinter as pupae in the soil. As the soil warms in the spring, it begin to develop. Adults begin to emerge from late May, and show peak activity during June to September (Kim and Kim, 2002). The emerged adults inhabit a forest or bush around pumpkin fields, and invade into the field of host plants when they have gotten physiological state for oviposition. Females lay eggs in the flesh of young pumpkin. The eggs hatch within 10 days or so, then the larvae feed while tunneling through the fruits. When heavy infestation is occur, the fruit decays before maturation. It takes about 30 days for the larvae to develop, and mature larvae escape from the fruit to pupate in the soil.

The pumpkin fruit fly was recorded for the first time in 1933 by Shiraki in Japan (Shiraki, 1933). In Korea, the pest was found first in Gwanyang-si, Jeollanam-Do in 1974, and thereafter observed in the whole country. Recently, the damage caused by the fly on pumpkin and water melon is increasing in alpine regions. However, no study was conducted to establish the control strategies of *B. depressus*. Although McPhail traps baited with yeat hydrolysate attract some *B. depressus* adults (Kim and Kim, 2002), the traps are not enough for the purpose of monitoring or control. A new methods which can monitor *B. depressus* populations are required primary for the successful control.

Host plant odors are known to be important in long-range host location by Tephritid female adults that are seeking for oviposition sites (Jong and Städler, 1999). Some flies display a series of ovipositional behavior that consists of landing, examining, egg deposition and postovipositional behaviors (Brockerhoff *et al.*, 1999). Understanding the exact oviposition behavior of *B. depressus* will be necessary to establish a bioassay protocol for screening oviposition stimulants or deterrents for the use of monitoring or controlling.

MATERIALS and METHODS

Rearing was conducted in a culture room and cage environments at 24 ± 1℃ and 40 to 70% RH. The LD 13:11 photoperiod had a photophase that included 12h with ≈2500lux, although the degree of brightness was variable according to the distance from light sources.

The pupae of *B. depressus* were collected from damaged pumpkins in a field in Gangwon Province, 2006. Emerged adults were maintained in a acrylic cage (42×30×35 cm) and provided sugar, hydrolyzed protein (enzymatic yeast hydrolysate), and water *ad libitum*. The oviposition behavior of *B. depressus* was continuously observed in the cage. The light intensity was 2,000 Lux on the top and 800 Lux on the bottom in the cage. A green pumpkin was provided as oviposition substrate. Total 68 observations were made to analyse the oviposition pattern of *B. depressus*.

RESULTS and DISCUSSION

Bactrocera depressus adult females performed a sequential step during their oviposition (Table 1, Fig. 1). Females examined the fruit surface with proboscis or tarsi after landing. Then, they came to a halt for expending of ovipositor followed by twisting and grooming of ovipositor. Next, females located egg-laying places after some wandering or examining the fruit surface. Finally, female adults drilled and deposited eggs into the fruits. Also, *B. depressus* females showed post-ovipositional behaviors such as expending-twisting-grooming of ovipositor and dragging of ovipositor on the fruit surface, which possibly represented a host marking behavior.

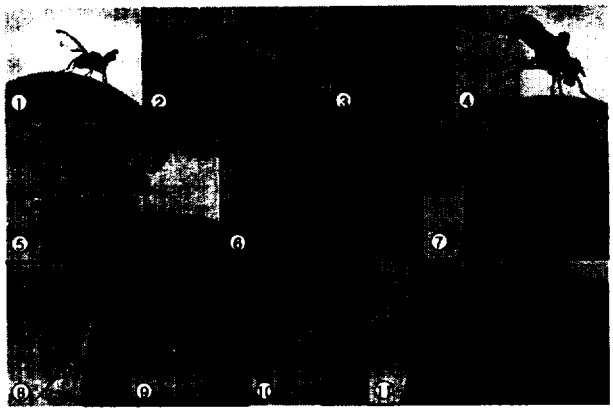

Fig. 1. The oviposition behavior of pumpkin fruit fly: Landing & examining fruit surface with proboscis or tarsi (①), expending (②) - twisting (③) - grooming (④) of ovipositor, locating oviposition place with proboscis and tarsi (⑤), drilling (⑥) & egg deposition (⑦), expending (⑧) - twisting (⑨) - grooming (⑩)cca of ovipositor after oviposition, and dragging of ovipositor (⑪).

Females displayed major two types of behavioral pattern, the full and reduced sequences (Table 1). Most female (91.2%) showed the full sequence and some (8.8%) went directly to the step of locating oviposition place after landing without examining the fruit and expending, twisting or grooming ovipositor.

Many fruit flies show a stepwise pattern of oviposition behavior. A famous example is the oviposition behavior of the cabbage root fly, *Delia radicum*. Stadlerand and Schoni (1990) described as; A, short visit without any exploration of leaf; B, rest, usually grooming; C, leaf run with exploration of surface (proboscis, tarsi); D, straight geotactic run on leaf borders, veins, stalk, and stem (leaf-stem run); E, horizontal, circular run around stem heading the ground (circular run); F, walk stem to ground, probing the sand surface; G, oviposition and attempts; H, climbing hack on stem, dragging the ovipositor. From the C pattern the flies can return to pattern B. After some time, the exploration activity begins again, i.e., the flies return to pattern C or fly away. Some of the stimulated flies underwent the whole sequence of preoviposition (patterns B-C), oviposition and postoviposition behavior (pattern D-H). This sequence could be interrupted by departure at any of the steps described. *Bactrocera depressus* females showed a similar behavior with those of *D. radicum* between behavioral steps such as

Table. 1. Two types of behavioral step in the ovipositional sequence of pumpkin fruit fly in the laboratory.

Type	Landing	Examining Fruit with proboscis & tarsi	Expending-Twisting-Grooming of Ovipositor	Locating Oviposition Place (proboscis, tarsi)	Drilling and Egg Deposition	Behaviors after Oviposition		Observed frequency (n=68)
						Expending-Twisting-Grooming of Ovipositor	Dragging of Ovipositor	
I	Y	Y	Y	Y	Y	Y	Y or N	91.2 %
II	Y	N	N	Y	Y	Y	Y or N	8.8 %

The sign Y and N indicate 'yes' and 'no', respectively.

grooming and the exploration of surface with proboscis.

Also, spruce cone fly, *Strobilomyia neanthracina* has a characteristic ovipostion behavior (Brockerhoff et. al., 199). In the greenhouse, the typical ovipositional sequence lasted an average of 7 min and consisted of landing on the cone and examining it with the proboscis and sometimes the ovipositor, egg deposition, and postovipositional behaviors such as tapping (touching the cone surface with the flabellum ca. 5 times per second), which possibly represents a host marking behavior. The postovipositional behavior such tapping is considered that the female flies mark something chemicals on host plants to prevent overcrowding oviposition. The tapping behavior of *S. neanthracina* was seen less frequently in the field than in the greenhouse, but occurred significantly more often after sequences that resulted in egg deposition than after sequences that did not (Brockerhoff *et. al.*, 199). The females of *B. depressus* showed a dragging behavior of ovipositor on the fruit surface, which may be a host marking behavior. However, the dragging behavior was not obligative. Some females left without dragging ovipositor on the fruit surface after successful oviposition. The Mediterranean fruit fly, *Ceratitis capitata* (Weidemann), females always mark the oviposition site after oviposition (Warburg *et al.*, 1997; Demirel, 1999).

The Mediterranean fruit fly damages the host plant by laying eggs underneath the epidermis (Averill, 1996). Females alighting on a fruit thoroughly examine the potential host before oviposition. Mediterranean fruit fly females probably prefer to choose a permanent host for an ovipostion site on the basis of attractive volatiles emitted from the host plant rather than temporary host plants (Light *et al.*, 1992). Plant volatiles seem to have great effects on the induction of oviposition of fruit flies. Cabbage root fly, *D. radicum*, females displayed the same sequence of behavioral patterns as on a natural host plant (Städler and Schöni, 990), on surrogate plastic leaves coated with a thin layer of paraffin wax and treated with 0.1 gram leaf equivalent of an ethanolic raw cabbage extract. A chemical cue may operate in the oviposition of *B. depressus*. Further studies are required for this.

Understanding such behavior is very important not only to control the target pest on the crops, but also getting the highest profit for the fruit crop production in the world. There are very extensive control methods for fruit flies when searching for articles about the pests. However, no effective control tools for *B. depressus* are developed yet. We suggest research on *B. depressus* behavior and trapping control methods be used together in future experiments that may decrease the population in economic crops.

적 요

호박과실파리(*Bactrocera depressus*) 파리목 과실파리과에 속한 곤충으로 박과류 작물의 중요한 해충이다. 이 해충은 다양한 수출용 과채류에 피해를 주는 것으로 알려져 있고, 외국에서는 심각한 검역해충으로 취급하고 있다. 호박과실파리의 정확한 산란행동을 구명하는 것은 산란자극제 또는 저해제 등의 생물검정법 수립을 위하여 필요하다. 호박과실파리 순차적 산란행동을 실내 사육용기(42×30×35 cm) 환경에서 관찰하였다. 실내온도는 24 ± 1 ℃이었으며, 사육용기의 조도는 상단부 2,000 Lux, 바닥 800 Lux로 조절되었다. 산란대상 재료로 애호박을 이용하였다. 전형적인 산란행동은 순차적 단계를 보였다. 즉 과실에 착륙 후 주둥이(proboscis) 또는 부절(tarsi)을 이용한 과실표면 검사 그리고 그 후 산란관 신장-비틂-손질, 주둥이로 과실표면을 검사하면서 산란장소 선택, 천공 및 산란, 그리고 산란 후 행동으로써 산란관 신장-비틂-손질 및 과실표면에 산란관 끌기 등 이었다. 암컷 성충은 두 가지 형태의 산란행동을 보였다. 관찰된 성충중에서 91.2%는 모든 단계의 산란행동을 보였으며, 8.8%는 착륙 후 곧바로 산란장소 탐색 단계로 이행하는 생략된 산란행동을 보였다.

검색어 : 호박과실파리, 호박, 산란행동, 산란관 손질, 산란관 끌기

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