

FEMALE CALLING BEHAVIOR IN *EPHESTIA ELUTELLA* AND *E. FIGULILELLA* (LEPIDOPTERA: PYRALIDAE)

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ABSTRACT

The sexual calling behavior of *Ephestia elutella* (Hübner) and *E. figulilella* Gregson females was observed in the laboratory under a 14L:10D photoperiodic regime. *E. elutella* females showed a broad mid-scotophase peak of calling activity with low levels of calling continuing throughout the photophase. *E. figulilella* females showed a narrower mid-scotophase calling peak with little or no photophase activity.

RESUMEN

El comportamiento de las hembras en "llamar", eso es, atraer a los machos, fue observado en 2 especies, *Ephestia elutella* (Hubner) y *E. figulilella* Gregson en un laboratorio debajo un regimen de fotoperíodo de 14L: 10 D. Hembras de *E. elutella* mostraron un pico ancho de actividad de llamar en el medio del período de oscuridad, con niveles bajos de esta actividad siguiendo por todo el período de luz. Las hembras de *E. figulilella* mostraron un pico más angosto en el medio del período de oscuridad, con poca o ninguna actividad en el periodo de luz.

Ephestia elutella (Hübner) and *E. figulilella* Gregson frequently occur, and are often found in sympatry with 3 other stored-product infesting phycitid moths: *Plodia interpunctella* (Hübner), *E. kuenhiella* Zeller, and *E. cautella* (Walker) (Reed and Livingstone 1937, Donahoe et al. 1949, Hoppe and Levinson 1979). Inasmuch as the primary component of the female sex pheromone (Z,E)-9,12-tetradecadien-1-ol acetate (ZETA) is the same in all 5 species (Brady and Daley 1972), and the males of any 1 species can be attracted to and attempt to mate with a female of any of the other species (Ganyard and Brady 1972, Krasnoff, unpublished data) it was hypothesized that differences in diel periodicity of sexual activity might help to maintain reproductive isolation in this group.

Daily rhythms underlying various aspects of sexual behavior and physiology have been studied in 3 stored-product infesting phycitid moths, *P. interpunctella* (Nordlund and Brady 1974, Coffelt et al. 1978), *E. kuenhiella* (Calvert and Corbet 1973), and *E. cautella* (Coffelt et al. 1978).

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However, the literature contains only anecdotal references to the diel sexual rhythms of the 2 other stored-products Phycitinae, *E. figulilella* (Cox 1974), and *E. elutella* (Reed and Livingstone 1937).

A laboratory study of the daily calling cycles of *E. elutella* and *E. figulilella* was undertaken to complete the picture of temporal partitioning of sexual calling in the stored-products Phycitinae, as well as to provide a foundation for a study of the courtship behavior of these 2 species.

MATERIALS AND METHODS

REARING AND HANDLING. *Ephestia elutella* were obtained from a colony maintained since 1961 at the USDA Tobacco Storage Insects Research Unit in Richmond, VA. *E. figulilella* were derived from a 15-year-old colony maintained at the USDA Stored-Product Insects Research Laboratory, Fresno, CA. Larvae of both species were reared according to the methods of Silhacek and Miller (1972). An autoclaved diet (Coffelt et al. 1979) was used for *E. figulilella* larvae which were found to be highly susceptible to disease. Cultures of larvae were maintained on a 14L:10D photoperiod at $26 \pm 1^\circ\text{C}$ and ca. 50% RH. A fluorescent lamp provided ca. 190 lux during the photophase. Scotophase illumination was ca. 5 lux from a red incandescent lamp (both measured 1 m from source). Insects were segregated by sex as pupae.

As female pupae became available they were divided into 3 groups and placed in 19.5 x 13.5 x 10.0-cm vented-plastic containers. These containers, in turn were placed in each of three 60 x 60 x 60-cm plexiglass chambers equipped with opaque cloth hoods so that the photoperiod could be maintained without interference from extraneous light. The photocycle in each chamber was offset from that in each of the others by 8 h. Thus hourly observations for 24 h of the daily cycle could be taken in 8 h. A light-board with an array of nine 7.5-W incandescent bulbs (5 white and 4 red) provided ca. 50 and 10 lux at 30 cm during the photophase and scotophase, respectively. Only red light was used during the scotophase. Insects were placed in these chambers early in the pupal stadium so that they would entrain to the offset photocycles before eclosion (Nordlund and Brady 1974). Temperature in the chambers was 24-27°C.

Insects that emerged each day were segregated into groups of 5-15 in cylindrical plastic containers (7 cm x 9 cm diam) and provided with a piece of fluted construction paper as a perch. Hourly counts were made of the number of calling females ("strong calling" *sensu* Nordlund and Brady 1974).

In another experiment, conducted only with *E. elutella*, 3- to 4-day-old unmated females (ca. 120) were released from vented mason jars placed in the center of the floor of a 2.5 x 1.4 x 2.0-m room during the last hour of the photophase. After 15 min a count was taken of the number of females on each surface (walls, ceiling, floor) and observations were made on the direction in which each female on the wall was facing (up, down, sideways). These counts were taken again 4 h later and the results compared with those of the 1st count.

RESULTS

Both *E. elutella* and *E. figulilella* females assume the characteristic phyci-

tine calling posture (Richards and Thomson 1932). The abdomen is flexed dorsally and the ovipositor is exerted. The female pheromone gland in both of these species is located on the ventral aspect of the membrane between the 8th and 9th abdominal segments, and is homologous to that of *P. interpunctella* (Smithwick and Brady 1977a,b).

Although rhythmic retraction and extrusion of the ovipositor has been noted in several lepidopteran species (Conner 1979 and references therein), this behavior was not observed in either *E. figulilella* or *E. elutella*. Females of both species, however, beat their antennae while calling (ca. 175 beats/min for *E. figulilella*, and 80 beats/min for *E. elutella*). Often *E. elutella* females initiating a calling bout were observed to pulse the dorsally flexed abdomen vigorously up and down for a few seconds before bringing it into the full calling position.

The calling behavior of both *E. elutella* and *E. figulilella* females showed distinct diel periodicities. *E. elutella* females had a broad peak of calling activity during the scotophase and continued to call at low levels during the photophase (Fig. 1). *E. figulilella* females also showed a maximum calling response during mid-scotophase, but with little if any calling during the photophase. The breadth of the peak in *E. elutella* was greater than in *E. figulilella*, such that >50% of *E. elutella* females exhibited calling from the 2nd through the 8th h of the scotophase, whereas >50% of the *E. figulilella* females exhibited calling from only the 3rd through the 6th h.

At 15 minutes after the onset of darkness, most of the females on the walls were facing up. This simply reflects the fact that they were released from the floor, flew up to the walls, landed face-up, and remained facing up until calling began. By the middle of the calling period (4 h after dark)

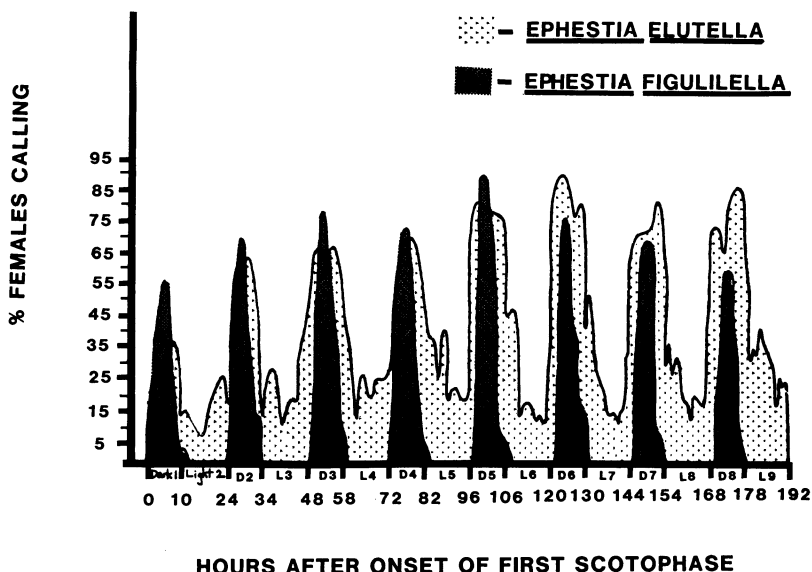


Fig. 1. Temporal distribution of calling in *Ephestia figulilella* and *E. elutella* females. Percentages are based on at least 25 observations.

most of the females on the walls were facing down ($\chi^2 = 69.0$, $p \ll .005$). An apparent preference for vertical surfaces was detected in *E. elutella* in the room-release study in which a significantly higher number of females ($p < .005$) took positions on the walls than on the ceiling or floor (Table 1).

DISCUSSION

The periodicity of the calling behavior of *E. elutella* females in a light:dark regime resembles that of *P. interpunctella* (Nordlund and Brady 1974) in 3 ways: 1) the activity peak is broad, 2) the peak occurs during mid-scotophase, and 3) moderate levels of calling activity are maintained during the photophase. These species are, in effect, photoperiodic "generalists", adapted to living in enclosed stores and food-processing plants cut off from natural illumination, and subjected to irregular or non-existent photocycles. In contrast, *E. figulilella*, an habitu  of open storage areas, has a sharper calling peak and lacks daylight calling.

If the information from the present study is integrated with that from studies of the other species in this complex (Traynier 1970, Steele 1970, Nordlund and Brady 1974), it may be possible to draw some conclusions about temporal partitioning of sexual calling in this group (Fig. 2). *P. interpunctella* and *E. elutella* would be likely candidates for temporal isolation from one another because they often co-occur, and they share not only the same primary component in the female sex pheromone but a secondary component as well (Krasnoff, Vick and Coffelt, unpubl. data). However, they clearly are not temporally isolated on the basis of female calling periodicity.

The calling periods of the 3 remaining species do seem to be discrete enough from each other to possibly provide some degree of reproductive isolation, assuming that time of day of male responsiveness approximately corresponds to time of day of female calling. A comparative study of naturally occurring populations of these species is needed to determine whether the temporal position of any species where it co-occurs with another (or others) in the group, differs from its position where it is isolated from the other(s). Documentation of this type of character displacement

TABLE 1. LOCATION AND POSITION PREFERENCE FOR *Ephestia elutella* FEMALES IN A ROOM-RELEASE STUDY (FLYING FEMALES WERE NOT SCORED).

	Surface (position)					χ^2 ^a
	Floor	Ceiling	Wall			
			(facing up)	(facing side)	(facing down)	
Lights-out						
+ 15 min	14	2	82	5	5	10.9
Lights-out						
+ 4 h	6	2	27	7	58	15.3

^aRelative proportion of total available surface area for each surface (wall, ceiling, floor) was used to calculate expected values.

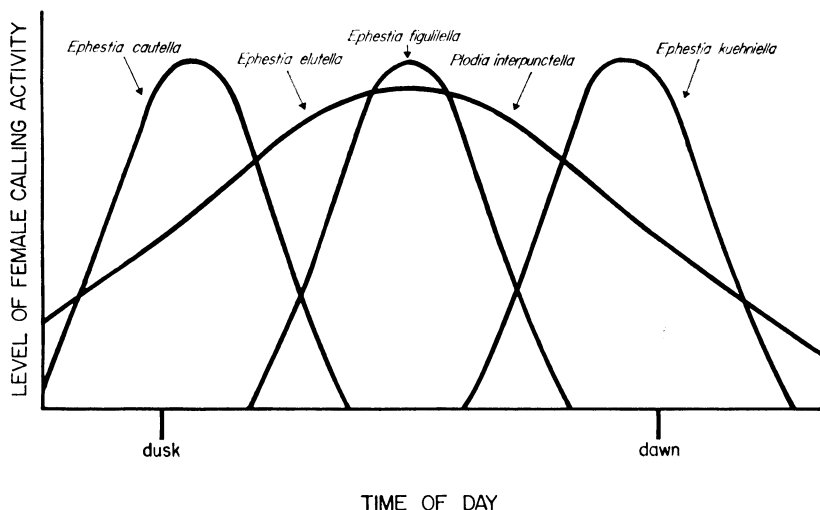


Fig. 2. Diel periodicity of female calling activity in stored-product Phycitinae.

would support the hypothesis that species-specificity of the diel sexual activity period actually evolved in a context of reproductive isolation.

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