

OVIPOSITION BEHAVIOR AND SITE PREFERENCE OF THE BROWNBANDED COCKROACH, *SUPELLA LONGIPALPA* (F.) (DICTYOPTERA: BLATTELLIDAE)

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(Accepted for publication 15 June 1988)

ABSTRACT

Oviposition behavior and site preference for oothecal deposition by *Supella longipalpa* (F.) females were investigated. The behavioral sequence and oviposition site preference were determined by type of substrate, substrate location and presence of other oothecae. Of 192 oothecae deposited in an oviposition site preference experiment, 74.5% were on corrugated cardboard, 24.5% were buried in sand and 1.0% were deposited on Plexiglas®. In an insectary where a free-living infestation of *S. longipalpa* was established, 72.4% of the oothecae found were in clusters of two or more with 92.5% of all the oothecae found on the upper third of the walls. These findings may have applicability in the control of *S. longipalpa*. Traps with corrugated interiors placed in high, dark locations may provide an effective means to identify and monitor *S. longipalpa* populations and provide a cluster focus for oothecal accumulation for either destruction or improved parasitism by naturally occurring parasitoids.

Key Words: *Supella longipalpa*, brownbanded cockroach, oviposition, control

J. Entomol. Sci. 24(1): 84-91 (January 1989)

INTRODUCTION

The brownbanded cockroach, *Supella longipalpa* (F.), believed to be of African origin, was first reported in the United States by Rehn in 1903 at Key West, Fla. It is a significant urban pest in the southern United States (Back 1937; Flock 1941) and is quickly spreading throughout the world (Bell 1981). The habit of attaching oothecae to furniture and other household objects (Ebeling 1978) and an incubation period of ca. 40 to 90 days, depending on temperature, (Gould and Deay 1940; Cornwell 1968) has resulted in the dissemination of *S. longipalpa* over great distances. Often, oothecae are attached in large clusters (Gordh 1973; Ebeling 1978). *S. longipalpa* attach their oothecae to substrates by means of a sticky genital fluid exuded over the ootheca at deposition (McKittrick 1964). This aids in concealment of the ootheca by attaching particles of debris to it when it is buried in a substrate such as sand.

In considering control, Van Driesche and Hulbert (1983) found the genital fluid acts as a kairomone for host acceptance by the parasitoid wasp *Comperia merceti* (Compere). *C. merceti* has had some success in reducing *S. longipalpa* infestations (Zimmerman 1948; Slater et al. 1980; Coler et al. 1984). However, reduced

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effectiveness in the ability of *C. merceti* to parasitize oothecae at lower densities (Coler et al. 1984) and the increasing pest status of this cockroach (Bell 1981) warrant further study of *S. longipalpa* oviposition behavior as well as its preferences for oviposition sites. This was the goal of the investigation presented here.

MATERIALS AND METHODS

Oviposition Behavior

Two types of containers were used to observe ovipositional sequences by *S. longipalpa*. Container I was a 37.8 l glass tank (24.5 cm wide \times 49.0 cm long \times 30.5 cm high) with 0.3 cm of dry sand covering the bottom. This was similar to the design used by McKittrick (1964). Container II was a 3.78 l glass jar without sand. A 9.5 cm \times 17.2 cm \times 0.2 cm piece of Plexiglas® or vertically grooved corrugated cardboard was inserted at a 30° upright angle to vertical in each jar used. The Plexiglas® and corrugated cardboard were used to simulate either the smooth or crack and crevice substrates that *S. longipalpa* might encounter as oviposition sites in a home. Three jars with Plexiglas® and three jars with cardboard were used. All containers were covered with gauze cloth and the inner rims were coated with a petroleum jelly and mineral oil mixture (1:1) to prevent cockroaches from escaping. Water vials and food (Purina® dog chow) were provided *ad lib*. The environment was maintained at 27°C \pm 2°C with 50% \pm 5% r.h. The laboratory was kept on a 12 h light: 12 h dark photoperiod. All observations were made in low, diffuse light during the dark period between 2000 and 0200 EST.

Thirty females and 15 males were placed in the 37.8 l glass tank. Five females and five males were placed in each of the six 3.78 l glass jars. Eight oviposition sequences on sand, 10 oviposition sequences on Plexiglas®, and seven sequences on corrugated cardboard were recorded. Where feasible, the length of time was recorded for each part of the ovipositional sequence on the different substrates. However, on the corrugated cardboard and Plexiglas®, where the activity of *S. longipalpa* was often reduced, the exact moment a particular phase of the ovipositional sequence either began or ended was difficult to ascertain. The major emphasis of this part of the investigation was the determination of variations in the ovipositional sequence on different substrates and not the specific timing or frequencies of each behavioral event.

Oviposition Site Preference

To evaluate oviposition site preference, a 37.8 l glass tank with 0.3 cm of sand on the bottom was used. A 9.5 cm \times 17.2 cm \times 0.2 cm piece of Plexiglas® and a vertically grooved piece of corrugated cardboard of the same dimensions, both at a 30° upright angle from vertical, were placed in the tank. The container and laboratory conditions were maintained as previously described. Thirty females and 15 males were kept in the tank for a 6 wk period. At 6 wks, the number and distribution of oothecae on each of the available substrates were recorded. The observed oothecal distribution was evaluated by chi-square analysis (X^2).

The last study investigated preference for oviposition sites by *S. longipalpa* in an insectary in which escaped individuals had established an infestation. The insectary had 29.5 m² of floor space with walls 3.3 m high. The walls were cinder block with floor to ceiling shelves around the room. Most shelves contained cockroach colony jars and miscellaneous items. All items, shelves, door jambs and other obstructions that concealed floor, wall, or ceiling voids were removed, and

the room was thoroughly searched for oothecae. Descriptive statistics including frequency distributions were used to evaluate these data.

RESULTS

Oviposition Behavior

Oviposition behavior observed on sand and corrugated cardboard corresponded closely with McKittrick's description except for what she termed "brief searching period" (1964: 85). In these observations, *S. longipalpa* females ovipositing on sand or corrugated cardboard searched for oviposition sites for what we considered prolonged periods of time (Table 1), ranging from 20 min. to 5 h. The oviposition sequence usually began during the dark phase in the laboratory, approximately 24 h after an ootheca was visible from the genital opening of the females observed.

On sand, females wandered about, stopping every 15 to 60 sec to palpate the surface. This phase was observed for $59.19 \text{ min} \pm 22.33 \text{ min}$. On corrugated cardboard females bearing oothecae also wandered about, palpating the surface, however they moved less frequently and spent longer periods over one location. Thus, it was difficult to ascertain the exact moment at which searching for oviposition sites began versus general activity. However, females that were observed ovipositing did so after a period of wandering and palpating the substrate for 3 to 5 h.

Within 20 to 90 min before oothecal deposition, on both substrates, females began excavations. Females on corrugated cardboard made some digging movements, but tended to palpate depressed areas of the surface more (Table 1). If the inspected location on either surface was not chosen as the final deposition site, searching was continued.

On sand, *S. longipalpa* females eventually chose a final site for hole preparation. Females excavated the final sites for $22.69 \text{ min} \pm 12.25 \text{ min}$ by kicking a prothoracic leg in an inward to outward-sideways motion. Only one leg kicked at a time, with legs alternated occasionally. When the hole was finished, females turned 180° , reared up on their prothoracic legs, forming an oblique angle to the hole, and oviposited in $3.06 \text{ min} \pm 0.58 \text{ min}$. After the ootheca was deposited, a drop of genital fluid was exuded over it. Females then rotated 180° again, faced the ootheca, grasped it with their mandibles and positioned it into the hole. This phase lasted $0.87 \text{ min} \pm 0.33 \text{ min}$. The hole covering phase followed with the prothoracic legs moving from outward to inward, continuing $28.18 \text{ min} \pm 7.26 \text{ min}$ until the ootheca was well concealed (Table 1). When the sequence was complete, females left the area and returned to an inactive state. Oviposition behavior was similar in the first female to oviposit at a location and subsequent females ovipositing at the same site.

On corrugated cardboard, there was no clear distinction between *S. longipalpa* behavior of palpating and digging movements during the later wandering search phase and the final choice for a deposition site. The behavioral sequence was the same for the first three females to oviposit in each jar and the subsequent four females observed. However, all four of the subsequent females chose a deposition site around established oothecae. When females were finished with inspection of the final deposition site, they turned 180° as on sand, reared up, and oviposited into the groove within ca. $3.0 \text{ min} \pm 1.0 \text{ min}$. As on sand, the genital fluid was exuded which caused the oothecae to adhere to the cardboard. Females then rotated 180° to their former position but manipulation of the ootheca with the

Table 1. Oviposition sequences of *Supella longipalpa* on sand, corrugated cardboard and Plexiglas®.

Sand all females	Corrugated Cardboard		Plexiglas®	
	all females	first females	subsequent females	
Prolonged wandering search with hole digging, palpation	Prolonged wandering search with attempted hole digging, palpation	Prolonged stationary search with palpation	Prolonged stationary search with palpation	
Hole preparation				
Oviposition	Oviposition	Oviposition	Oviposition	
Rotation	Rotation		Rotation	
Manipulation				
	Palpation		Palpation	
Hole covering	Some hole covering movements			

mandibles was absent during these observations. Females again palpated the deposition site, occasionally making some hole covering movements with their legs. Eventually, females would either leave the area or return to an inactive state.

Females attempting to oviposit on Plexiglas® showed a reduced activity level and oviposition sequence. The first females observed ovipositing in each jar stood over one spot for up to 5 h. During this period, searching behavior was confined to occasional palpation of the area, with females rearing up on their prothoracic legs as seen prior to oviposition on other substrates. Oviposition finally occurred including production of genital fluid to attach the ootheca to the Plexiglas®. With the rotation phase being absent, it was difficult to time deposition of the ootheca from the initiation of the behavior. However, as with the other depositions observed, it took ca. 2 to 4 min to deposit the ootheca. Females then left the area without any further activity. Besides rotation, wandering search, hole excavation and covering was absent in the first individuals to oviposit on Plexiglas®.

After the first oothecae were deposited on the Plexiglas®, they became foci for the seven subsequent oviposition sequences observed. Females ready to oviposit searched to a limited extent but inspected fewer sites for longer periods of time than those on sand or corrugated cardboard. The search phase continued for $216.9 \text{ min} \pm 44.41 \text{ min}$. Inspection was usually concentrated around established oothecae and was made by palpation. Females were observed to spend 60 to 180 min of their search at the final oviposition site, around established oothecae. During actual oviposition, females turned 180° to the deposition site, reared up and oviposited within $3.12 \text{ min} \pm 0.31 \text{ min}$ in the same manner as females on sand and corrugated cardboard. Oothecae were deposited as before, with genital fluid exuded, gluing the new ootheca to established ones. After oviposition, subsequent females, in contrast to the first females, inspected their newly laid ootheca by palpation (Table 1) for $46.30 \text{ min} \pm 15.23 \text{ min}$. Wandering search, excavation, manipulation by the mandibles and covering movements were absent.

Oviposition Site Preference

In the oviposition site preference experiment the oothecae were not statistically uniform in distribution ($X^2 = 162.1$, $P < 0.001$, $df = 2$). Of 192 oothecae deposited, 74.5% were on corrugated cardboard, 24.5% were buried in sand and 1.0% were on Plexiglas®.

Of 127 oothecae found during the insectary inspection, 72.4% were discovered in clusters of two or more (Table 2). One cluster of 12 was found behind the door jamb and a group of seven were located in a cinder block crevice behind some boxes. All oothecae were placed either on shelves or glued to walls. Overall, most oothecae (92.5%) were on the upper third of the walls (2.2 - 3.3 m high).

DISCUSSION

Oviposition Behavior

Except for prolonged searching, the oviposition sequence of *S. longipalpa* closely followed that described by McKittrick (1964). In behavioral observations on sand, the prolonged searching phase appeared to be appetitive in nature. Discovery of a suitable oviposition site seemed to be the stimulus for the innate sequence of excavation, oviposition, emplacement and covering of the ootheca. This stimulus may be a characteristic of the substrate, an established ootheca, or both.

Table 2. Oothecal cluster sizes for a free-living population of *Supella longipalpa* (F.) in an insectary (area = 29.5 m²).

Number of oothecae per cluster	Frequency of occurrence	Frequency distribution, %
1	35	27.6
2	30	47.2
3	3	7.1
4	1	3.1
5	0	-
6	0	-
7	1	5.5
8	0	-
9	0	-
10	0	-
11	0	-
12	1	9.5
≥13	0	-

On surfaces where *S. longipalpa* was unable to dig, McKittrick (1964) noticed that females ready to oviposit made a few kicking strokes, often at several locations and then oviposited in a crevice followed by a few covering strokes. The oviposition sequence observed on corrugated cardboard closely followed this description. Crevices in corrugated cardboard seemed to be a sufficient stimulus to release the active searching and oviposition sequence. The main difference was that palpation of the oviposition site appeared to replace actual hole digging, manipulation with the mandibles and covering phases (Table 1).

On Plexiglas®, lack of substrate stimuli seemed to modify normal searching and digging phases (Table 1). First females spent more time stationary, inspecting potential oviposition sites. Apparently, females either had to perceive the correct stimuli in the right sequence or a certain amount of time had to elapse before oviposition could take place.

When one or more oothecae were present on Plexiglas®, subsequent females tended to oviposit in the same area. These females were more active in searching and palpating potential deposition sites. Also, when other oothecae were present, subsequent females tended to spend less time inspecting the final deposition site than did the first ovipositing female. This may indicate that oothecae were providing an additional positive stimulus for oviposition. After oviposition, these females inspected the deposition site by palpation which may have been the functional equivalent of manipulation with the mandibles and the hole covering phase.

Oviposition Site Preference

In the site preference experiment, it was notable that *S. longipalpa* exhibited a three-fold preference for corrugated cardboard over sand. The presence of grooves may act as a trigger for oviposition, accounting for the majority of oothecae being deposited on cardboard. Perhaps substrates such as bark or cracks in rocks forming longitudinal channels separated by partitions is the preferred natural site

of oothecal deposition by *S. longipalpa*. Unfortunately, little information regarding the natural history of *S. longipalpa* is available.

Overall, behavioral and site preference variations during oviposition may be regarded as preadaptations by *S. longipalpa* for the change from its natural to its urban habitats. In this regard, one of the interesting questions of cockroach biology is why only approximately two dozen species have become urban pests out of approximately 4,000 species (Frishman 1982). In some cases, answers will be physiological mechanisms, or behavioral mechanisms, or both. Whatever the answer, the important item for future research in cockroach biology will be recognizing adaptive mechanisms in present-day pest species and identifying wild species with a potential for becoming domiciliary.

Van Driesche and Hulbert (1983) found the genital fluid used by *S. longipalpa* to fix its oothecae to substrates serves as a kairomone for host acceptance by the parasitoid *C. merceti*. The genital fluid originally may have had a pheromonal function since many kairomones are pheromones exploited by other organisms to the detriment of the emitter (Matthews and Matthews 1978). Since *S. longipalpa* nymphs are known to be gregarious (Gould and Deay 1940; Roth and Willis 1960; Rust and Appel 1985) and that aggregation favors growth and development of cockroach nymphs (Willis et al. 1958; Izutsu et al. 1970), pheromonal cues for clustering of oothecae may have developed in *S. longipalpa* to allow hatching nymphs to aggregate. This phenomenon may explain the distribution of oothecae in the insectary.

Gould and Deay (1940) reported that *S. longipalpa* prefer high locations, such as shelves in closets. This is consistent with our findings of 92.5% of the oothecae in the upper third of the walls and shelf areas of the insectary. Since *S. longipalpa* prefer higher regions of the room, females may have first found several suitable harborages and oviposition sites. These would be represented by finding single oothecae. Over time, the most desirable oviposition sites, such as those behind objects on shelves or inside door jambs, may be chosen by one or more females as deposition sites. These more secure, concealed places could be locations where a presumed pheromone could become more important as a cue for oothecal deposition.

Outdoors, in tropical and sub-tropical regions, there may be numerous suitable oviposition sites in areas where *S. longipalpa* is present. Therefore an oothecal pheromone for clustering may be beneficial by establishing a center where many nymphs are in close proximity for aggregation. However, the introduction of *S. longipalpa* into temperate regions required it to seek refuge in indoor habitats with controlled temperatures. Indoors, the number of suitable oviposition sites may be limited. Thus, a pheromonal cue from the oothecae may cause clustering of oothecae in less than optimal areas for concealment and protection. This, in turn, would benefit *C. merceti* in finding its host.

By knowing the preference of *S. longipalpa* for deposition sites and substrates, better techniques including traps can be developed for their control. Moore and Granovsky (1983) compared the efficacy of four commercially available sticky traps with smooth interiors and an aromatic food source in catching five principal cockroach pests including *S. longipalpa*. They reported that *S. longipalpa* was least likely to be caught and the least likely to oviposit in the traps. Perhaps traps with corrugated interiors placed in high, dark areas might be more effective for *S. longipalpa* capture or oothecal accumulation. If a pheromonal component could be isolated from the genital fluid and used in the trap, its efficiency might improve

further. Such traps could be used to identify and monitor a population and provide a focus for deposition of oothecae either for their destruction or for the enhancement of parasitism by *C. merceti*. Any or all of these strategies would be an improvement over current control measures used against this urban pest.

ACKNOWLEDGMENTS

We sincerely thank Vincent Capone and Jim Schupsky for their valuable laboratory assistance. We greatly appreciate the helpful comments by Peter Adler, Vivienne Huber, Patricia Zungoli and two anonymous reviewers in preparing this manuscript.

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