DIEL OVIPOSITION PATTERNS OF *ANOPHELES ALBITARSIS* IN TRINIDAD, WEST INDIES

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ABSTRACT. The diel pattern of oviposition of wild-caught *Anopheles albitarsis* derived from rice fields in Frederick Settlement, Trinidad, was studied in the laboratory by recording the performance of egg-laying individuals and a colony at 2-h intervals. Oviposition was almost exclusively nocturnal, with 79.3% of the eggs being laid during the scotophase. During the rest of the day and during evening twilight, 7.8 and 12.9% eggs were laid, respectively. Wild-caught parous females allowed to engorge on human blood matured, on average, 71.1 ± 12.4 follicles (range 53–106). These findings provide vector control personnel with the opportunity to maximize the impact of insecticides on *An. albitarsis* populations by restricting their operations to the time of peak activity.

INTRODUCTION

Anopheles albitarsis Lynch-Arribalzaga is a vector of malaria in South America (Downs et al. 1943, Rubio-Palis et al. 1992). Within its geographical range *An. albitarsis* breeds primarily in rice fields (Downs et al. 1943) and is markedly exophilic in feeding behavior (Chadee 1992a). Senior-White (1953) reported the collection of adults from 1740 to 2000 h and further demonstrated that the biting of *An. albitarsis* peaked 20 min after sunset. Similar results were subsequently reported by Chadee (1992a). Nothing is known about the diel oviposition pattern of *An. albitarsis* in the field and in the laboratory. The acquisition of such information is long overdue because of the need to conduct mosquito control programs in areas where rice cultivation exists in close proximity to human settlements. In Trinidad, *An. albitarsis* serves both as a potential vector of malaria should cases of malaria be imported but also as a severe nuisance to villages where extensive rice cultivations exist (Chadee 1992a). The results of a laboratory study on the diel patterns of oviposition of *An. albitarsis* are presented here.

MATERIALS AND METHODS

Wild *An. albitarsis* females were collected from Frederick Settlement (10°36'N, 61°25'W), a village located on the Caroni Savannah Road and the Southern Main Road, ~5 km west of the Piarco International Airport, Trinidad. The Caroni River flows on the northern side of the village, whereas the eastern, western, and southern sides contain >1,500 ha of rice cultivation. The rice fields provide the most important larval habitat for *An. albitarsis*. The study area, vegetation, topography, and populations of *An. albitarsis* have been described by Chadee (1992a).

Mosquito collections were made between 1800 and 1900 h, the peak landing times of *An. albitarsis* (Chadee 1992a). Six men were stationed in the rice fields. Mosquitoes were collected using the methodology described by Chadee (1994). Mosquitoes were stored and transported in accordance with methods outlined by Aitken (1960) and Chadee (1994).

At the Insect Vector Control Division laboratory, mosquitoes were lightly anesthetized with chloroform, identified, and counted under a microscope at 40× magnification. *Anopheles albitarsis* with any trace of blood as well as other species were discarded. All *An. albitarsis* mosquitoes that did not succumb to the light anesthetic after identification were placed into a colony cage (30 × 30 × 30 cm) consisting of wire netting enclosing a wood frame. In the cage, adults were provided *ad libitum* with a 10% solution of glucose dispensed from a white cotton wick. The indoor insectary, lighting regimen, temperature, and humidity profiles have been previously described by Chadee (1992b). Suntime was used during the monitoring of oviposition and is used throughout the report. During this study sunset fell between 1804 and 1808 h and sunrise between 0628 and 0629 hours. On the second day after collection all dead mosquitoes were discarded and females were allowed to engorge on blood from the experimenter's arm exposed in the cage for 20 min at about 1830 h, a time close to the evening peak of landing and biting of *An. albitarsis* (Chadee 1992a).

One day later, 40 engorged females (condition assessed by eye) were removed by aspirator from the colony cage and each placed into a separate oviposition cage, identical to the colony cage. Each oviposition cage was furnished *ad libitum* with a sugar cube in an uncovered Petri dish. By segregating females in this way we were able to record the diel periodicity of each individual and

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Table 1.   Diel pattern of oviposition of individual and colony *Anopheles albitarsis* mosquitoes.

Suntime (h)	No. of eggs laid per time interval							
	Individuals				Colony			
	$\bar{x}$	%	Mw[1]	%	$\bar{x}$	%	Mw[1]	%
0600–0800	0	0	0	0	0	0	0	0
0800–1000	0	0	0	0	0	0	0	0
1000–1200	38.0	4.7	4.1	2.5	84.4	5.1	11.4	1.7
1200–1400	0	0	0	0	0	0	0	0
1400–1600	27.5	3.4	3.9	2.4	40.0	2.4	4.9	0.7
1600–1800	23.0	2.8	4.7	2.9	15.6	1.0	5.8	0.9
1800–2000	163.5	20.0	20.9	12.9	342.2	20.8	77.9	11.7
2000–2200	425.0	52.0	112.6	69.3	876.7	53.2	517.4	77.5
2200–2400	140.0	17.1	16.3	10.0	287.8	17.5	50.1	7.5
2400–0600	0	0	0	0	0	0	0	0
Total	817.0	100.0	162.5	100.0	1,646.7	100.0	667.5	100.0

[1] Williams' mean.

thus assess the contribution each made to the composite periodicity, a powerful procedure used first by Gillett (1962).

From about 36 h after engorgement (i.e., about 1800 h on the day after engorgement) oviposition

Fig. 1.   Diel pattern of oviposition by *Anopheles albitarsis* in the laboratory, shown by: A. Mean number of eggs laid by isolated females; B. Occurrence of eggs in cages with isolated females; C. Mean number of eggs laid by females in colony (———), Williams' mean.

was monitored by exposing in each cage 4 small white polyethylene tubs (diameter of top 10 and bottom 8 cm, height 8 cm, capacity 550 ml) painted black outside, containing 300 ml of rice-field water. A fresh tub was prepared using temperature-equilibrated rice-field water about 10 min before being placed in a cage. The diel periodicity of oviposition was monitored by replacing an old tub with a freshly prepared one every 2 h. To change tubs in 40 cages took about 20 min, so changing began a few minutes before and finished a few minutes after the scheduled time. Monitoring continued according to this schedule in the 40 cages and concurrently in the colony cage from 0600 h on the 2nd day after engorgement until 0600 hours on the 5th day (i.e., continuously for 3 24-h periods). By recording separately the oviposition periodicity of females segregated individually and females in the colony cage, we allowed for possible effects of interference among females (Corbet and Chadee 1993), even though the number of females (about 150) in the colony cage was relatively small. Immediately after monitoring ceased, all females in individual cages were killed and dissected, and any relict eggs counted and recorded. When possible, the parity status of each female was determined (Detinova 1962). In this way the fecundity (the complement of matured follicles) for each female was measured. Oviposition data from individuals and the colony were analyzed separately. Records of the numbers of eggs laid in successive time intervals are given either as the arithmetic mean or as the Williams's mean (Haddow 1960) (see Table 1).
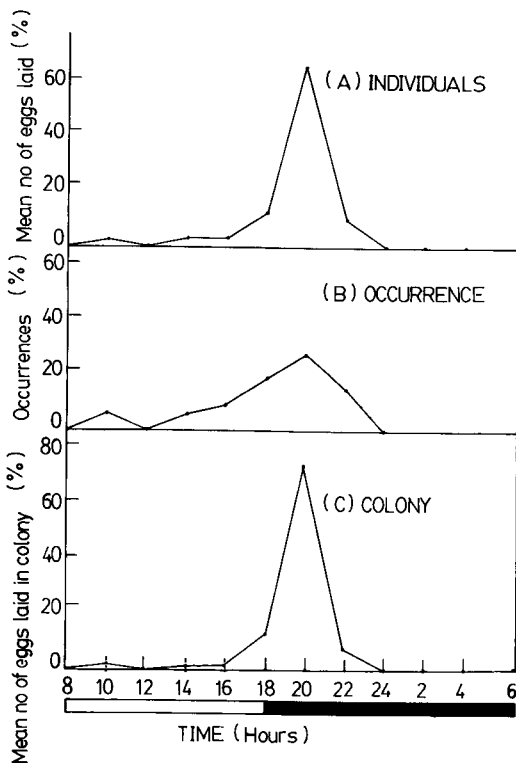
RESULTS

The oviposition pattern of *An. albitarsis* is shown in Table 1 and Fig. 1. The patterns derived

from numbers of eggs laid and occurrence of eggs corresponds closely, as do the arithmetic and Williams's means.

Of the 40 females observed individually, 30 laid eggs during the 3-day observation period. Among the 30 females that laid eggs, 9 retained eggs (either 2, 30, 39, 53, 67, 70, 74, 81, 82). Oviposition of the isolated females occurred during diurnal, crepuscular, and nocturnal periods, with the majority being crepuscular and nocturnal: 1,132 eggs (69.3% of the eggs laid and 56.6% of the occurrences) were laid during the night (i.e., 2000–2400 h), and 327 eggs (12.9% of the eggs and 20.0% of the occurrences) were laid during and after evening twilight (1800–2000 h).

In the individual cages, a well-defined oviposition peak (comprising 52% of the eggs laid and 40% of the occurrences) fell between 2000 and 2200 h. Oviposition activity began during the day (1000–1200 h), steadily increased during the evening twilight, with a low level of crepuscular activity, reached peak activity between 2000 and 2200 h, and abruptly declining after midnight.

In the colony cage, a very similar oviposition periodicity was observed (Table 1 and Fig. 1). All eggs were laid between 1000 and 2400 h but significantly more eggs (77.5%) were laid during the nocturnal period ($G = 49.7$, df 6, $P < 0.001$) than at any other time. Oviposition started and finished at the same time among both individuals and colony mosquitoes (see Table 1).

The fecundity of the 30 individual females averaged 71.1 ± 12.4 follicles (range 53–106). Ranges of 50–69, 70–89, and 90–109 follicles were matured by 7, 12, and 11 gravid females, respectively. Counts included retained eggs and so were independent of whether a female had laid any or all of her egg complement. Most females dissected for parity determination were parous (P2s and P3s), suggesting that they were old females. It was not possible to determine the parity of some females with relict eggs.

DISCUSSION

The oviposition periodicity for *An. albitarsis* in the laboratory was well defined with a single, nocturnal peak. This was very similar to that observed for *Anopheles culicifacies* Giles, *Anopheles stephensi* Liston, and *Anopheles subpictus* Grasse (Panicker et al. 1981), but different from *Anopheles gambiae* Giles (Haddow and Ssenkubuge 1962), *Anopheles albimanus* Wied., and *Anopheles freeborni* Aitken (Chadee et al. 1993).

Using the single female per cage methodology, it was determined that *An. albitarsis* females usually laid their whole complement of eggs during one bout of oviposition and never spread oviposition over 2 consecutive days. Twenty-five females laid their whole complement of eggs within a 4-h period (2 consecutive monitoring intervals). The fecundity of parous *An. albitarsis* mosquitoes observed ($\bar{x} = 71.1$ eggs/female) is the only information available on this aspect of the biology of this species.

The time of peak oviposition activity observed during the present study corresponds to a similar peak in the biting activity of *An. albitarsis* in Venezuela (Rubio-Palis and Curtis 1992) and in Trinidad (Senior-White 1953, Chadee 1992a). Both activities fell between 1800 and 2200 h, suggesting that 2 activities concurrently occurred after twilight and midnight. In addition, malaria transmission to humans occurs at a similar time period between 1800 and 2400 h in rice-growing areas (Downs et al. 1943, Rubio-Palis et al. 1992). This conclusion will be of interest to control personnel who wish to restrict pesticide fogging to the time of greatest effectiveness. Now that the diel oviposition periodicity of *An. albitarsis* in the laboratory has been characterized, it would be of value to conduct similar studies in the field, for planning a rational control strategy against this vector of malaria.

ACKNOWLEDGMENTS

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