FIELD OBSERVATIONS ON THE SWARMING BEHAVIOR OF *ARMIGERES SUBALBATUS* (COQ) (DIPTERA : CULICIDAE)

AR Rajavel

Vector Control Research Centre (ICMR), Medical Complex, Indira Nagar, Pondicherry 605006, India

Abstract. Swarming behavior of *Armigeres subalbatus* was observed in Pondicherry, South India. Swarming occurred both at dawn and dusk over stationary markers. The duration of swarming was longer at dusk (135 minutes) and shorter at dawn (75 minutes). Higher intensity in terms of relative density of participating males was observed at dusk when compared to dawn. Peak swarming activity was observed at light intensity ranging between 10 and 183 lux. Response to low light intensity of 1-10 lux was different during dawn and dusk. At this intensity initiation took place at dawn and termination was seen at dusk. Mating pairs were seen in the swarm. Analysis of the composition of swarms showed a male to female ratio of 1:0.01 at dusk and 1:0.02 at dawn. Besides nulliparous females, a few one parous and two parous females were also obtained from the swarm.

INTRODUCTION

The behavior of swarming, characteristic of many of the Diptera, was considered as a quasi-stationary flight over a landmark, often undertaken by many insects together, and during which mating takes place (Downes, 1969). Howard *et al* (1912) were of the view that swarm constituted the gathering and hovering of males in the form of a cloud, to which the females seem to be attracted. This flight has been studied in different mosquito species of the three genera *Anopheles* (Rao and Russell, 1938; Marchand, 1984), *Culex* (Kawai *et al,* 1967; Kaul and Wattal, 1978) and *Aedes* (Nielsen, 1985; Gomulski, 1988). Among *Armigeres,* Basio and Magluyan (1977) have reported on the swarming behavior of *Ar. malayi. Ar. subalbatus,* a prime nuisance species in urban areas has remained unobserved for this behavior until now. Field observations on the swarming activity of *Ar. subalbatus* were made in Pondicherry, South India, where it breeds profusely in septic tanks (Rajavel, 1992), and the results are presented in this communication.

MATERIALS AND METHODS

Observations on swarming behavior of *Ar. subalbatus* were done in localities where swarming occurred regularly. For quantitative analysis, a total of eight observations at dusk and six at dawn was made, commencing well before the initiation of swarming. Samples were collected by sweep net, making three sweeps each time at intervals of 15 minutes. The relative density of mosquitos obtained in each sample was taken as an index of the intensity of the swarm at different periods from initiation to termination. The time and light intensity at initiation and termination of swarm besides light intensity at each sampling were recorded. A lux meter (INS digital lux meter with a measuring range of 0-10,000 lux and accuracy ± 2% of Rdg ± 1 digit) was used for this purpose with the sensor facing the sky, but not exactly pointing to the sun. Sampling was continued until the sweeps yielded no mosquitos, denoting the termination of the swarm.

The number of samples obtained varied with the duration of swarming activity in different observations. Also, there was wide variation in the light intensity, especially at higher values, at the initiation of swarms at dusk and termination at dawn. The relationship between swarming and light intensity was, therefore, determined by plotting the average number of males against the mean light intensity (lux) obtained at each sampling starting from initiation up to termination, from all the observations.

Mosquitos collected were brought to the laboratory and the number of male and female recorded separately. The males were checked for completion of genitalia rotation immediately on arrival from the field. The abdominal condition of the females was recorded. Dissection of the ovary was done and parity status determined based on dilatations

(Detinova, 1962). Spermathecae were removed on to a drop of saline in a microscopic slide and pressed lightly with a cover glass and observed for the presence of sperms to determine insemination.

RESULTS

Swarming was usually initiated by two or three males and increased in numbers attaining a peak, followed by a gradual decline to termination. At dusk, swarming commenced around 16.00 hours and subsequent sampling at 15 minutes interval showed a gradual build up of density with a peak after 45-90 minutes of the initiation of the swarm. This was followed by a decline until termination after 120-135 minutes from initiation. At dawn, swarming commenced around 5.30 hours and attained a peak after 30-45 minutes. Termination was observed after 60-75 minutes. Swarming activity was thus longer (135 minutes) at dusk and shorter (75 minutes) at dawn.

The relative density recorded in different samples in different observations ranged between 1-45 at dusk and 1-26 at dawn. The mean (± SD) relative density at dusk (17.5 ± 13.75) was significantly ($T = 2.63$, $df = 51$, $p = 0.01$) higher than that at dawn (8.35 ± 5.7).

The initiation of swarming activity at dusk was observed at a light intensity around 880-2240 lux in different observations, but termination in all the observations was observed when light intensity fell down to 0. In contrast, swarming at dawn commenced at day break when light intensity recorded 1 in all observations while termination occurred at light intensity between 187-565 lux in different observations. The peak density ($x = 35.5$) at dusk which reflects the peak in the swarming activity was recorded when light intensity_ranged between 42-183 lux with a mean (± SD) of 116.25 ± 50.01 (Fig 1a). Though the peak ($x = 14.8$) observed during dawn was at the light intensity of 10-37 lux with a mean (± SD) of 19 ± 9.88 (Fig 1b) it persisted until the next sampling which recorded a light intensity ranging between 59-157. When the rate of change in the light intensity at this level was compared between dusk and dawn, it was higher in dusk. This would have facilitated the decline in the swarming activity following a peak at dusk. It appears that the light intensity ranging between 10-183 lux favors a high swarming activity.

Sampling for the composition of the swarm (Table 1) showed that the male to female ratio was

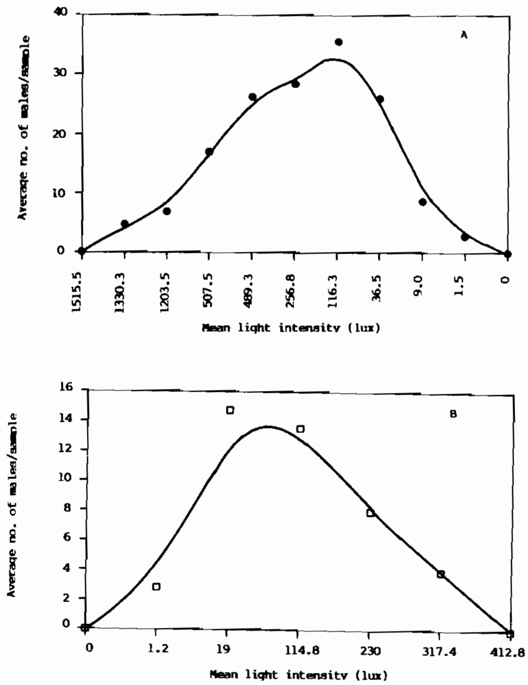

Fig 1–Swarming in relation to light intensity at dusk (a) and dawn (b).

1:0.01 at dusk and 1:0.02 at dawn. When the abdominal condition of the females collected at dusk was analysed it was found that 67.9% were unfed. However, full fed, semigravid and gravid females were also recorded. Dissection of ovary for parity status revealed that 64.3% of the females were nulliparous, but one parous and two parous females also took part in the swarm.

Examination of male terminalia for rotation showed that majority of the males had completed rotation. However, a few were exception to this and such males constituted 1.4% at dusk and 0.32% at dawn.

DISCUSSION

The observation of swarming of *Cx. pipiens* over some prominent object such as a tree or a projecting branch by Knab (1906) is perhaps the earliest report on swarming of mosquitos. In the present observation, swarming of *Ar. subalbatus* was found to occur along the side of hedges, over a heap of tiles, rotting wood and bush. Such orientation of mosquito swarms over contrasting and sharply defined points

Table 1

Composition of dusk and dawn swarms.

Period	No. collected		M:F ratio	Abdominal condition				Parity status			Insemination	
	Male	Female		UF	FF	SG	G	NP	1D	2D	No.	%
Dusk	2,204	28	1:0.01	19	2	4	3	18	8	2	21	75.00
Dawn	309	6	1:0.02	2	1	1	2	6	0	0	4	66.66

M:F = Male to female; NP = Nulliparous; UF = Unfed; 1D = parous; FF = Full fed; 2D = Two parous; SG = Semigravid; G = Gravid

has often been observed in nature (Bates, 1949). However, swarming of *Ar. subalbatus* never occurred over moving markers, as reported for *Cx. p. fatigans* by Menon and Rajagopalan (1975). The swarm as a unit also remained in a place from initiation to termination and within it the males were observed to be in constant motion, each describing a pattern of 8. Similar flight pattern was observed in *Psorophora columbiae* (Peloquin and Olson, 1985) and Gibson (1985) has found *Cx. p. quinquefasciatus* to perform such elliptical loops while swarming. Occasionally the males of *Ar. subalbatus* deviated from this pattern to go into circular motions. Thus, individuals did not have fixed positions but drifted within the swarm.

Unlike the swarming period of 20-22 minutes reported for *Ar. malayi* by Basio and Magluyan (1977), the duration of Swarming in *Ar. subalbatus* was longer, extending to 75 minutes at dawn and 135 minutes at dusk. The swarming periods of 11 minutes in *Ae. albopictus* (Basio and Magluyan, 1977), 20 minutes in *An. arabiensis* (Marchand, 1984), 25 minutes in *Cx. annulirostris* (Russell, 1985) and 3-34 minutes in *Cx. p.fatigans* (Kaul and Wattal, 1978), which are comparatively shorter, suggests that prolonged swarming activity is unique to *Ar. subalbatus.*

Sampling of the swarm yielded small number of females. The presence of females in the swarm could not be accidentàl as swarming is generally considered as the occasion of mating. Observations showed mating pairs within the swarm. The female on entering the swarm was chased by a number of males and eventually pairing took place. Similar pairing of sexes within the swarm was observed in *Cx. p.quinquefasciatus* by Williams and Patterson (1969) but they attributed the meeting of the sexes to chance, as there was no seeking of the opposite sex by either the males or females. Pairing and increases in percentage of insemination in *Cx. tarsalis* was reported to occur concurrently with swarming at dusk and to a lesser extent at dawn by Reisen *et al* (1985). Higher proportion of inseminated females in dusk swarm, observed in this study, may be attributed to the presence of parous, semi gravid and gravid females, which might have been inseminated earlier. Analysis of insemination rate in nulliparous unfed and fullfed females alone showed that the percentage did not differ significantly ($p = 0.64$) between dawn and dusk.

Light intensity as a factor influencing swarming has been wellestablished. In the case of species with crepuscular swarming habits, Bates (1949) observed that light would play an important role in influencing the formation of swarms. Swarming in *Ar. subalbatus* was also observed to be influenced by change in light intensity. Similarly, a gradual change in light intensity to a certain threshold level - 1 foot candle - has been found to induce swarming in *Cx. p.quinquefasciatus* (Williams and Patterson, 1969) and swarms of males of *An. culicifacies* has been reported to occur when light intensity fell below 2 foot candles (Russell and Rao, 1942). An interesting feature observed in *Ar. subalbatus* was that low intensity of light (1-10 lux) acted as the facilitating factor in initiating the swarm during dawn and in dispersal of swarm during dusk.

The range of light intensity within which swarming activity occurred in *Ar. subalbatus* was, however, wide unlike the narrow range of 55 to 1 lux observed for *An. arabiensis* (Marchand, 1984). Observation of mating in *Ae. niphadopsis* swarms that occurred at light intensities of 40-80 foot candles by Dickson (1982) is also not comparable with *Ar. subalbatus*. This wide range of light intensity utilised by *Ar. subalbatus* for swarming seems to be the probable reason for its prolonged swarming activity as compared to other mosquito species.

Though light is an important factor, observations which showed that swarming is not induced during the day when light intensity falls down due to weather conditions, suggest an endogenous rhythm in the swarming of *Ar. subalbatus*. Light should, therefore, act as a clue. Such functional relationship between effects of light on free-running and entrained circadian rhythm has been suggested by Pohl (1976). The view of Clements (1963) that an endogenous rhythm probably underlies the swarming of some, possibly all, swarming species, causing the males to swarm in response to low light intensities in the evening, and in some species also at dawn, seems to be applicable to *Ar. subalbatus*.

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REFERENCES

Basio RG, Magluyan LJ. On Philippine mosquitoes XVII. Swarming and landing/biting habits of some species. *Kalikasan* 1977; 4 : 198-204.

Bates M. The Natural History of Mosquitoes. New York : Macmillan, 1949; 379 pp.

Clements AN. The Physiology of Mosquitoes. Oxford : Pergamon Press, 1963; 393 pp.

Detinova TS. Age grouping methods in Diptera of medical importance. *WHO Monogr Ser* 1962; 47 : 69-77.

Dickson SL. Swarming and mating in *Aedes niphadopsis* Dyar and Knab. In : Rossay B, Collett GC, eds. Proceedings and papers of 35th Annual Meeting of Utah Mosquito Abatement Association, Utah, 1982.

Downes JA. The swarming and mating flight of Diptera. *Ann Rev Ent* 1969; 14 : 271-97.

Gibson G. Swarming behaviour of the mosquito *Culex pipiens quinquefasciatus:* a quantitative analysis. *Physiol Entomol* 1985; 3 : 283-96.

Gomulski L. Observations on the swarming behaviour of three species of *Aedes* mosquitoes in Britain. *Brit Mosq Group News* 1988; 5 : 5-7.

Howard LO, Dyar HG, Knab F. The mosquitoes of North and Central America and the West Indies. *Carnegie Inst Wash Publ* 1912; 1 : 120-31.

Kaul HN, Wattal BL. Field observations on the swarming and mating behaviour of *Culex pipiens fatigans* in Delhi. *J Commun Dis* 1978; 10 : 99-106.

Kawai S, Wada Y, Omori N. Preliminary note on the swarming of *Culex tritaeniorhynchus*. *Trop Med* 1967; 9 : 58-64.

Knab F. The swarming of *Culex pipiens*. *Psyche* 1906; 13 : 123-33.

Marchand RP. Field observations on swarming and mating in *Anopheles gambiae* mosquitoes in Tanzania. *Neth J Zool* 1984; 34 : 367-87.

Menon PKB, Rajagopalan PK. Some observations on resting and swarming behaviour of *Culex pipiens fatigans* in an urban situation. *WHO/VBC/75.555*, 1975.

Nielsen ET. Field flight behaviour. A. Swarming. In: Nayar JK, ed. Bionomics and physiology of *Aedes taeniorhynchus* and *Aedes sollicitans*, the salt marsh mosquitoes of Florida. 1985; 852 : 67-71.

Peloquin JJ, Olson JK. Observations on male swarms of *Psorophora columbiae* in Texas ricelands. *J Am Mosq Control Assoc* 1985; 1 : 482-88.

Pohl H. Proportional effect of light on entrained circadian rhythms in birds and mammals. *J Comp Physiol* 1976; 112 : 103-8.

Rajavel AR. Larval habitat of *Armigeres subalbatus* (Coq) and its characteristics in Pondicherry. *Southeast Asian J Trop Med Public Health* 1992; 3 : 470-3.

Rao TR, Russell PF. Some field observations on the swarming and pairing of mosquitoes, particularly *Anopheles annularis* in south India. *J Mal Inst Ind* 1938; 1 : 395-403.

Reisen WK, Knop NF, Peloquin JJ. Swarming and mating behaviour of laboratory and field strains of *C. tarsalis* (Diptera : Culicidae). *Ann Entomol Soc Am* 1985; 78 : 667-73.

Russell PF, Rao TR. On swarming, mating and oviposition behaviour of *Anopheles culicifacies*. *Am J Trop Med* 1942; 22 : 417-27.

Russell RC. Male swarming and mating behaviour in *Culex annulirostris* Skuse (Diptera : Culicidae) at Appin, NSW. *Gen Appl Entomology* 1985; 17 : 5-8.

Williams FM, Patterson RS. Swaming and mating behaviour in *Culex pipiens quinquefasciatus* Say. *Mosq News* 1969; 29 : 662-6.