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Swarming and Insemination of *Chironomus yoshimatsui* (Diptera, Chironomidae)

MASAHIRO KON

Department of Zoology, Faculty of Science, Kyoto University
Sakyo-ku, Kyoto, 606, Japan.

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Abstract. In *Chironomus yoshimatsui*, copulation has been observed to occur only in the aerial swarm. In order to know whether successful mating could occur on the ground and whether mating in the swarm actually contributed to insemination, the viability of egg masses of *C. yoshi- matsui* was investigated. Results clearly showed that: (1) Uninseminated egg masses were completely inviable. (2) No egg mass laid by a female confined in a small container with a mature male was viable. (3) The hatching rate was higher in egg masses laid by females mating in the swarm (86.49%) than in those by females which were believed to have not yet been captured by a swarming male (14.63%). It is concluded that swarming has an epigamic function and may be obligatory for mating in *Chironomus yoshimatsui*.

Two types of mating tactics, swarming and searching, are known in chironomid midges. In marine chironomids (Clunionini, Telmatogetonini and *Pontomyia*) and the Himalayan wingless glacier midge (*Diamesa* sp.), mating takes place only on the ground (or water) by searching and males do not have plumose antennae, which are regarded as specialized structures for detecting a female in the air by her flight sound (Hashimoto, 1962, 1976; Sunose & Fujisawa, 1982; Kohshima 1984).

However, in several species it has been reported that mating occurs both in the aerial swarm and on the ground (*Glyptotendipes paripes*: Nielsen, 1962; *Stictochironomus crassiforceps* [cited as *Allochironomus*]: Syrjämäki, 1964; *Pseudodiamesa arctica, Diamesa geminata* and 2 *Chaetocladius* spp.: Oliver, 1968; *Tokunagayusurika akamusi*: Sasa, 1978; Kon *et al.*, 1986).

Furthermore, mating in the aerial swarm has been observed in many species (*Spaniotoma minima, Metriocnemus longitarsus, Chironomus dorsalis*: Gibson, 1945; *C. strenzkei*: Syrjämäki, 1965; *C. pseudothummi*: Syrjämäki, 1966; *C. salinarius*: Koskinen, 1969; *C. plumosus*: Hilsenhoff, 1966, Römer & Rosin, 1969; *C. riparius*: Caspary & Downe, 1971; *C. thummi* and *C. piger*: Mielbradt & Neumann, 1976; *C. yoshimatsui*: Kon, 1984). However, in a few species it has been shown that mating can occur only in the air (*C. riparius*: Caspary & Downe, 1971).

In *C. yoshimatsui*, copulation has been observed to occur only in the aerial swarm (Kon, unpublished data). In order to investigate the possibility of copulation occurring on the ground and hence at places other than in the swarm, and whether the mating observed in the swarm actually contributed to insemination, the viability of egg masses laid by females of *C. yoshimatsui* was investigated.

Materials and Methods

The examined females of *C. yoshimatsui* belonged to 4 categories as follows:

1. virgin female reared in the laboratory.
2. virgin female confined for 3 days after emergence in a small container (2 cm diameter 3 cm height) with a mature male (1 day old or more), where contacts between both sexes occurred frequently.
3. female copulating in the swarm.
4. female flying to the swarm, apparently prior to having been captured by a swarming male.

The females of categories 3 and 4 were collected from a dusk swarm at a swarming site in the campus of Kyoto University in April, 1984.

Individual females of all categories were transferred in a small container with a little water, and left until they laid an egg mass. Under these conditions they usually oviposited within 2 days (Kon unpublished). A female of this species lays one egg mass in her lifetime comprising about 500 eggs. It takes 1 to 2 days for them to hatch at a room temperature (Shirota 1969). The egg masses were observed until either they hatched or all the eggs had died.

Results and Discussion

As shown in Table 1, uninseminated egg masses, laid by virgin females (category 1), completely failed to hatch. Similarly, no egg mass laid by females of category 2 was viable. It, therefore, seems certain that, in this species, no copulation can occur on the ground in spite of the frequent contact between both sexes in the small space. Copulation can probably occur only when both sexes meet in the air. It has also been shown in this species that no viable egg mass is oviposited when adults are maintained in a smaller cage (20 cm×40 cm×60 cm) but that viable eggs are produced when adults are maintained in a larger (50 cm×50 cm×200 cm) (Kon, unpublished data). This also suggests that it is necessary that both sexes meet in flight for successful mating. Experimental investigations of the activity patterns of this species showed that midges were not active at all except at swarming time (Kon, 1985) and they therefore seem to have no opportunity of meeting in flight except when swarming. Thus swarming appears to be an inevitable prerequisite to mating in *C. yoshimatsui*.

The hatching rate was much higher in category 3 than in category 4, or higher in females mating in the swarm than in those assumed to be prior to having been captured by

Table 1. Viability of egg masses laid by females.

Category of females	No. of viable egg masses /no. of egg masses examined	Percentage of viable egg masses (%)
1. Virgin female	0/22	(0)
2. Virgin female with a male in the small container	0/22	(0)
3. Female mating in the swarm	32/37	(86.49)
4. Female presumed to be before mating in the swarm	6/41	(14.63)

a swarming male (Table 1). This suggests that virgin females come to the swarm and are inseminated during the copulation with a swarming male. However, six out of 41 egg masses laid by the females of category 4 hatched. It is unknown where these females had been inseminated, but it is possible that females remaining in the swarm after mating were misidentified by the author as being females which had not been found by a swarming male.

Thus, this study clearly showed that, in *C. yoshimatsui*, mating may occur only in the aerial swarm and that the copulation observed in the swarm contributed to insemination. Swarming has an epigamic function and may be obligatory for mating in this species.

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著者： 近 雅博，〒606 京都市左京区北白川追分町，京都大学理学部動物学教室.