SEASONAL APPEARANCE AND SIZE OF EGG RAFTS OF *CULEX HALIFAXII* AND *CULEX FUSCANUS* IN OKINAWAJIMA, THE RYUKYU ARCHIPELAGO, JAPAN[1]

YUKO TOKUYAMA, TAKAKO TOMA AND ICHIRO MIYAGI

Laboratory of Medical Zoology, School of Health Science, Faculty of Medicine, University of the Ryukyus, 207 Uehara Nishihara, Nakagami, Okinawa 903-01, Japan

ABSTRACT. The seasonal chronology of eggs of *Culex halifaxii*, *Cx. fuscanus* and their cohabitant *Cx. quinquefasciatus* were observed from March 1984 to early May 1985 in Okinawa prefecture, Japan. In Okinawajima, egg rafts of *Cx. halifaxii* and *Cx. quinquefasciatus* were found throughout the year. The greatest peak in eggs of *Cx. halifaxii* were observed in early June. The egg rafts of *Cx. fuscanus* were first collected on June 15, with the greatest peak of oviposition in early November. The egg raft of *Cx. fuscanus* was larger and both the maximum and mean numbers of eggs per raft were approximately two times greater than those of *Cx. halifaxii*.

INTRODUCTION

It is well known that the larvae of the subgenus *Lutzia* of the genus *Culex* are predacious on larvae of other mosquitoes and in nature the females seldom feed on man. *Lutzia* is represented in Japan by three species, *Culex halifaxii* Theobald, *Cx. fuscanus* Wiedemann and *Cx. shinonagai* Tanaka, Mizusawa and Saugstad (Tanaka et al. 1979). *Culex halifaxii* is very common and widely distributed in Japan (except Hokkaido) and Southeast Asia. *Culex fuscanus* is a tropical Asian species and the Ryukyu Archipelago is its northernmost limit. The third species, *Cx. shinonagai*, is an endemic species on Ogasawara Island (Tanaka et al. 1979). *Culex halifaxii* is very similar to *Cx. fuscanus* ecologically and morphologically, and can be distinguished only in the adult stage; differences occur in abdominal ornamentation and male genitalia (Bram 1967, Toma and Miyagi 1986).

The *Lutzia* mosquitoes may play a beneficial role in reducing populations of economically important species, such as *Cx. quinquefasciatus* (Say), as they utilize the same type of habitat. However nothing is known of the bionomics and interrelationships between *Cx. halifaxii* and *Cx. fuscanus* in the Archipelago. In this paper, we will report on the bionomics, especially differences in the seasonal appearance and the number of the eggs per raft between *Cx. halifaxii* and *Cx. fuscanus* on Okinawajima.

MATERIALS AND METHODS

From March 1984 to early May 1985, observations were made to determine the seasonal abundance of the predacious species, *Cx. halifaxii* and *Cx. fuscanus*, and their principal prey, *Cx. quinquefasciatus*, at Ozato village in the south of Okinawajima.

Six artificial containers, 25 cm diam, and 3000 ml capacity, were placed along the wall of a building to serve as ovitraps. To provide a suitable medium for oviposition, straw or hay was put into the containers with water, and the medium in the containers was occasionally changed. All egg rafts in the six ovitraps were collected and counted every two days. The color and form of the *Lutzia* raft is characteristic (Berlin and Pandian 1973), typically deep-black and rhombic or rectangular and is readily distinguishable from that of *Cx. quinquefasciatus* which is brownish and typically long and boat-shaped. The number of eggs in the *Lutzia* rafts were counted. As it was not possible to distinguish between *Cx. fuscanus* and *Cx. halifaxii* egg rafts, the larvae were reared under outdoor conditions, and after emergence, identified by the abdominal ornamentation of the adult (Toma and Miyagi 1986). The number of eggs and rafts of *Cx. halifaxii* and *Cx. fuscanus* were recorded twice monthly. The total number of eggs for *Cx. quinquefasciatus* was estimated by determining the mean number of eggs per raft from 98 rafts randomly selected from the 3,120 egg rafts collected.

RESULTS AND DISCUSSION

The oviposition pattern for *Cx. halifaxii*, *Cx. fuscanus* and *Cx. quinquefasciatus* from March 1984 to early May 1985 and the twice monthly accumulated rainfall and mean temperature in Ozato village are shown in Fig. 1.

Egg rafts of *Cx. quinquefasciatus* were found throughout the year and the total number of rafts and eggs were 3,120 and approximately 443,040, respectively. The number of eggs increased gradually from April with the first and greatest peak of the year, with 70,858 eggs in

[1] This work was supported by Grant-in-Aid for Scientific Research 1984 (B, no. 59921037) from the Ministry of Education, Japan.

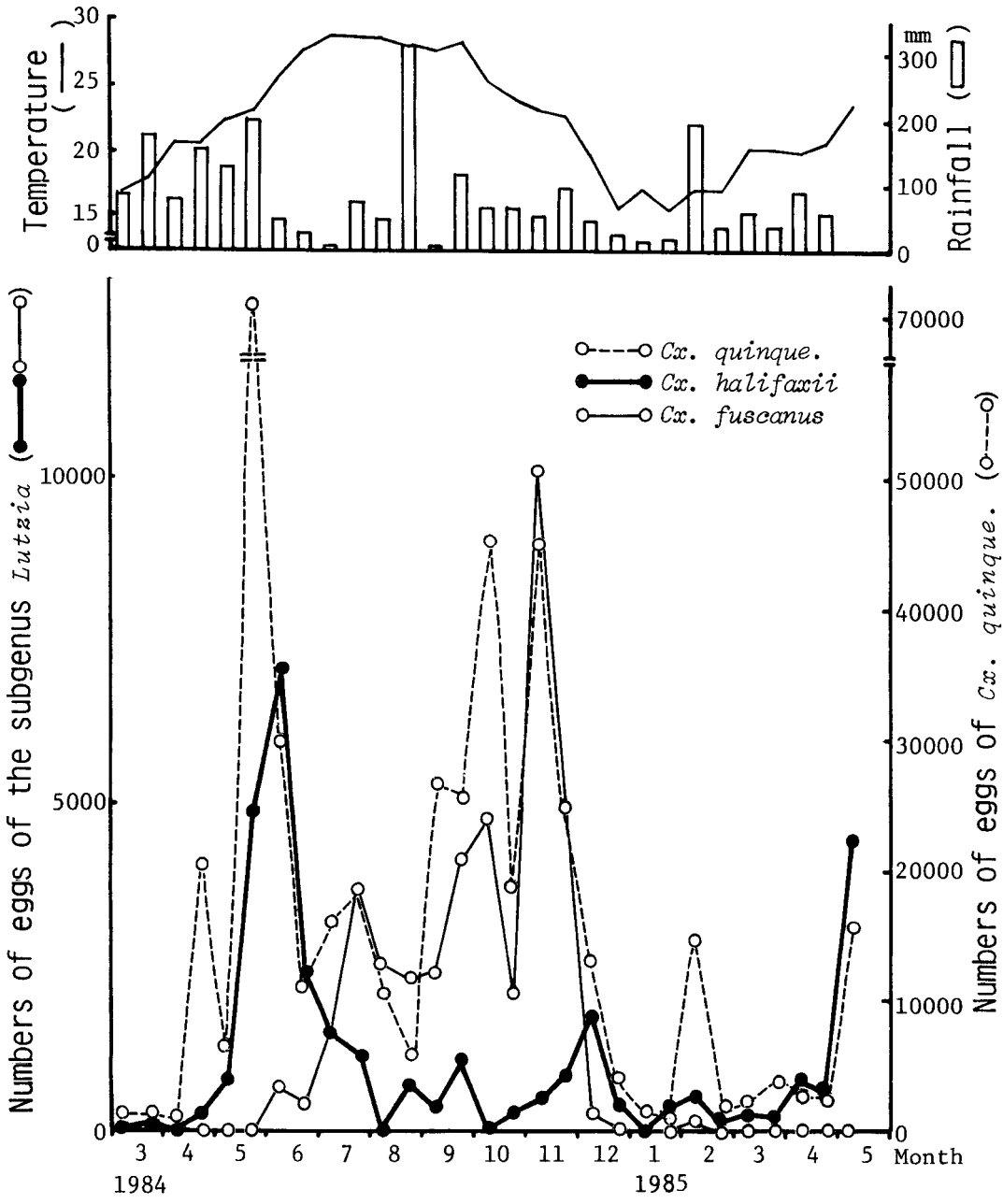

Fig. 1. Seasonal appearance of eggs of *Culex halifaxii*, *Cx. fuscanus* and *Cx. quinquefasciatus* in Ozato Village, Okinawajima.

499 rafts, in late May. Thereafter, numbers sharply decreased from June to August and increased again in September. The second peak occurred from early October to early November. Probably because of a typhoon with its strong winds and heavy rains, numbers decreased briefly in late October. Numbers sharply declined in December, and were lowest in the coldest month, January in 1985. The seasonal oviposition pattern of this species showed two peaks and was similar to the results obtained by Toma et al. (1978).

The egg rafts of *Cx. halifaxii* were also found throughout the year and the total number of rafts and eggs were 649 and 31,503, respectively. The greatest peak of oviposition was observed in early June, following that of *Cx. quinquefasciatus*. Subsequently numbers decreased gradu-

ally until early August. Small peaks occurred in late September and early December.

The total number of rafts and eggs of *Cx. fuscanus* collected were 428 and 40,396, respectively. Egg rafts were not found in the ovitraps from March to May 1984. Two rafts with 422 eggs were first collected on June 15, 1984; after that numbers increased from July to early November, but fluctuated widely. The greatest number of eggs occurred in early November with numbers sharply declining in December and very small from January through February. No rafts were collected during the period December 8, 1984–May 15, 1985 except for one raft with 142 eggs on February 6, 1985. During March to June 1984, the number of eggs of *Cx. halifaxii* was clearly greater than that of *Cx. fuscanus*. Subsequently the numbers decreased gradually and the proportions were reversed in early July. From July to November, *Cx. fuscanus* was more abundant than *Cx. halifaxii* but in early December numbers declined sharply and numbers of *Cx. halifaxii* were again greater than for *Cx. fuscanus*. The great number of *Cx. quinquefasciatus* may be preyed upon mainly by *Cx. halifaxii* from April to June and by *Cx. fuscanus* from September to November. A total of 1,077 egg rafts with 71,899 eggs of *Lutzia* species and 3,120 egg rafts with approximately 443,040 eggs of *Cx. quinquefasciatus* was collected throughout the year.

The number of eggs found in 519 rafts of *Cx. halifaxii* varied from 7 to 262 with a mean of 36 per raft (Fig. 2). About 80% of the rafts examined contained from 7 to 70 eggs per raft. Of the 343 rafts examined of *Cx. fuscanus*, the number of eggs varied from 7 to 412 with a mean of 80 per raft. Mean number of eggs per raft of those species was significantly different by t-test ($P < 0.01$). Although the egg rafts of *Cx. fuscanus* are approximately twice as large as those of *Cx. halifaxii*, the two species cannot be distinguished clearly by the size of the raft. As shown in Fig. 3, the number of eggs per egg raft was quite variable and a relationship between the size of the raft and month was not evident.

According to Toma and Miyagi (1986), the immatures are commonly found in a variety of artificial containers and tree holes with many kinds of mosquitoes, such as: *Cx. quinquefasciatus*, *Cx. pallidothorax* Theobald, *Cx. ryukyensis* Bohart, *Uranotaenia novobscura ryukyuana* Tanaka, Mizusawa and Saugstad, *Aedes aureostriatus okinawanus* Bohart, *Ae. albopictus* (Skuse), *Ae. flavopictus downsi* Bohart and Ingram, *Ae. riversi* Bohart and Ingram, *Orthopodomyia anopheloides* (Giles) and others in the Archipelago. It was found that the oviposition sites of the females of *Lutzia* species correspond closely to those of *Cx. quinquefasciatus* although the species is capable of tolerating higher levels of pollution (Ikeshoji 1966). These two predacious species have different seasonal chronologies in the same niche as *Cx. quinquefasciatus* which is preyed exclusively upon throughout the year in Okinawajima. In Okinawajima, *Cx. fus-*

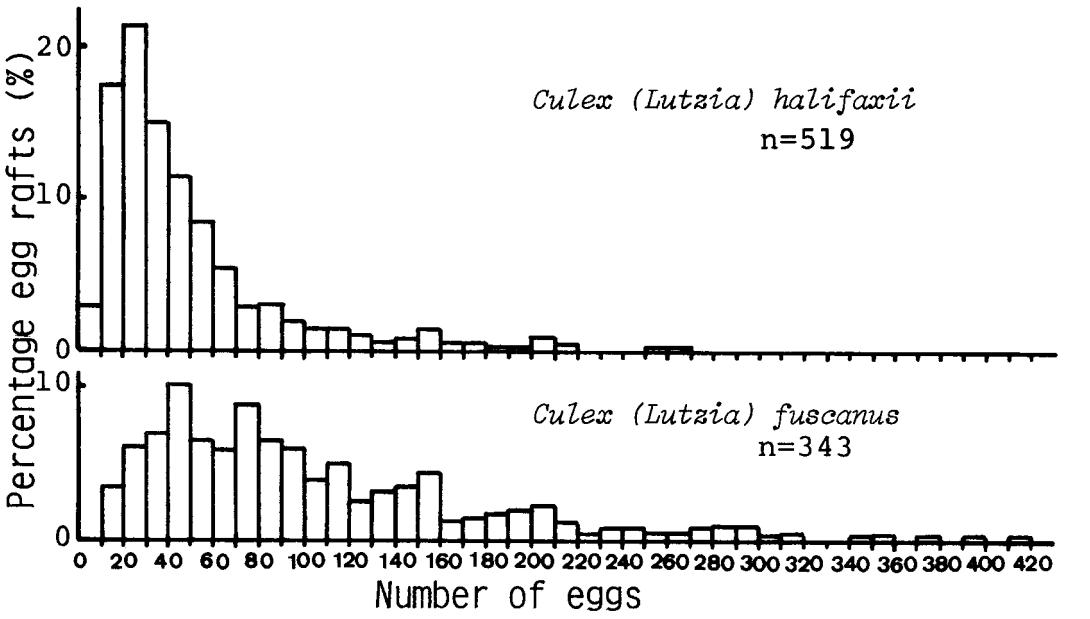

Fig. 2. Frequency distribution of the number of eggs per raft of *Culex halifaxii* and *Cx. fuscanus* in Ozato Village, Okinawajima.

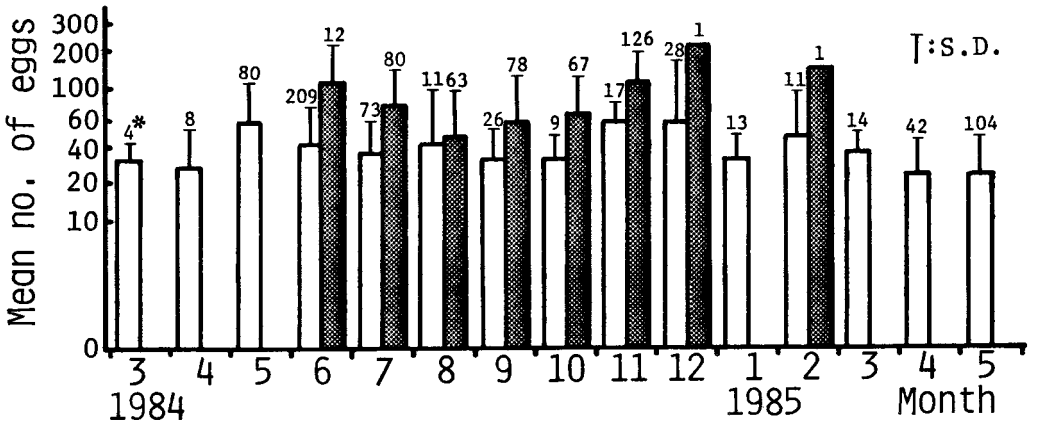

Fig. 3. Monthly mean number of eggs in rafts of *Culex halifaxii* (open bars) and *Cx. fuscanus* (solid bars) in Ozato Village, Okinawajima. * Number of egg rafts collected.

canus and *Cx. halifaxii* larvae are very common and may play an important role in reducing populations of *Cx. quinquefasciatus* under field conditions.

ACKNOWLEDGMENTS

We are grateful to Mr. Hiroshi Miyajima, School of Health Science, Faculty of Medicine, University of the Ryukyus, for helping with the field collection of the mosquitoes.

REFERENCES CITED

Berlin, O. G. W. and R. S. Pandian. 1973. Description of the egg of *Culex* (*Lutzia*) *fuscanus* Wiedemann (Diptera, Culicidae). Mosq. Syst. 5:277.

Bram, R. A. 1967. Contributions to the mosquito fauna of Southeast Asia. II. The genus *Culex* in Thailand (Diptera: Culicidae). Contrib. Am. Entomol. Inst. (Ann Arbor) 2:1–296.

Ikeshoji, T. 1966. Bionomics of *Culex* (*Lutzia*) *fuscanus*. Jap. J. Exp. Med. 30:321–334.

Tanaka, K., K. Mizusawa and E. S. Saugstad. 1979. Mosquitoes of Japan and Korea. Contrib. Am. Entomol. Inst. (Ann Arbor) 16:987 pp.

Toma, T. and I. Miyagi. 1986. The mosquito fauna of the Ryukyu Archipelago with identification, key, pupal descriptions and notes on biology, medical importance and distribution. Mosq. Syst. 18:1–109.

Toma, T., I. Miyagi, C. Hoshino and B. Sakumoto. 1978. Notes on mosquitoes collected by light traps in Naha city. Ryukyu Univ. J. Health Sci. Med. 1:96–100.