THE SEASONAL APPEARANCE OF *AEDES ALBOPICTUS* IN OKINAWAJIMA, THE RYUKYU ARCHIPELAGO, JAPAN[1]

TAKAKO TOMA, SHUJI SAKAMOTO AND ICHIRO MIYAGI

Laboratory of Medical Zoology, School of Health Sciences, Faculty of Medicine, University of the Ryukyus, Naha, Okinawa 902, Japan

ABSTRACT. The seasonal appearance of *Aedes albopictus* was observed from January 1978 to April 1979 in Naha city, Okinawa prefecture. In Okinawajima, all immature stages and adults were collected every month of the year. The highest density of immature stages was observed in July and their numbers then sharply decreasing through late August. The number of immatures increased again in September and then decreased gradually from October to February. The females fed readily on humans and oviposited on warm days in winter, and adult emergence occurred even in the coldest month.

Aedes albopictus (Skuse) is one of the vectors of dengue fever in Southeast Asia and Japan and is a very common mosquito which breeds in a wide variety of natural and artificial containers in human dwelling areas. It readily bites man in the shade during the day. The biology of *Ae. albopictus* in Japan proper, which belongs to the temperate region, had been observed mainly by Ito (1959), Makiya (1968, 1973, 1974) and Mori and Wada (1978). In Okinawa district, which is subtropical, very little is known about its biology, such as seasonal abundance, development of immature stages and feeding activity of the female. In order to formulate a successful control program for this species, it is necessary to know its biology in nature. In this paper, we discuss the seasonal abundance of the eggs, larvae and adults as measured by oviposition traps and human-baited catches during portions of 1978 and 1979 in Naha city, Okinawa prefecture.

MATERIALS AND METHODS

From January 7, 1978 to April 1, 1979, weekly observations were carried out at a flower garden which was located outside houses in Naha city, Okinawa prefecture, Japan. Five artificial containers, (3 larval and 2 egg counting containers), 13 cm in diam. and 500 ml in capacity, were placed in the garden. The number of each larval instar and pupae of *Ae. albopictus* in the 3 larval counting containers was tabulated. After counting, the average number of each larval instar and pupae per container was determined. The mosquito larvae and pupae, water and all other contents such as leaves and twigs were put back into the same containers as before. Mosquito larvae were not given any food. Strips of paper towels were placed in the 2 egg counting containers. The paper towels were removed from the containers, the number of eggs counted weekly and the average number of eggs per container was calculated. Adult females coming to bite from 2 p.m. to 4 p.m. were collected for 15 minutes in the garden using an aspirator tube and a sweep net and were counted. In order to determine the parous rate, most of these females were dissected under an binocular microscope.

RESULTS

Figure 1 shows 10-day average rainfall and temperature for Naha city during this study. The seasonal abundance of immature stages of *Ae. albopictus* from January 1978 to April 1979 in Naha city is given in Fig. 2. The number of immatures increased gradually from late April 1978 and the highest average density was observed in mid-July (the maximum average number was recorded on July 15,

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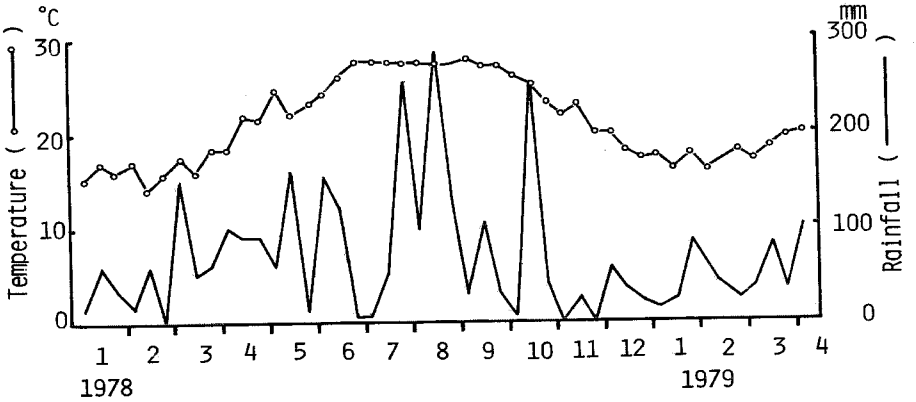

Fig. 1. Ten-day average rainfall and temperature for Naha city from 1978 to 1979.

1978). Immature numbers sharply decreased until late August, increased gradually to a smaller mid-September peak, then fell gradually but irregularly to a low in February. The winter immature population was very low and varied from year to year. To show the seasonal changes in the numbers of immature stages in detail, average population counts for each larval instar and the pupae are shown in Fig. 3. A strong peak of first instar larvae was observed in early June, with the maximum average number recorded on June 10, 1978. In late June, the first instar larval population sharply decreased, increased again in mid-July and early September. After that, it fell gradually from mid-October and became

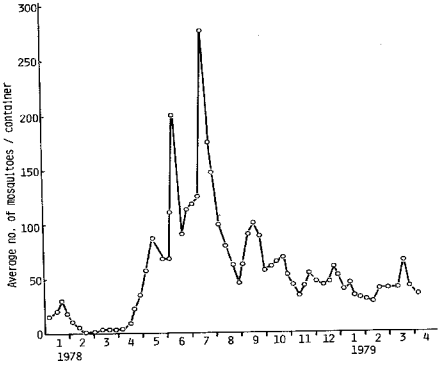

Fig. 2. Seasonal abundance of immature stages of *Ae. albopictus* in Naha, Okinawa.

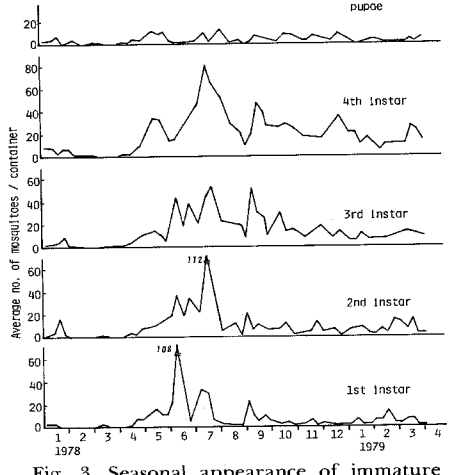

Fig. 3. Seasonal appearance of immature stages of *Ae. albopictus* in Naha, Okinawa.

very low during the cold months. Greatest peaks of second, third and fourth instar larvae were observed in mid-July, late July and mid-July respectively and after that, they sharply decreased until early September. The number of second to fourth instar larvae in winter varied from year to year, and were higher in 1979 than 1978. Pupae were collected every month and fluctuations in the pupal population were relatively small throughout the season.

The proportions of pupae to all immature stages are given in Fig. 4. The proportions were very high through January to April, but low through June to July. The high proportion indicates that there were very few newly hatched larvae at this time and that the emergence of adults was delayed during the winter season. This low proportion results from the large number of younger instar larvae in June and July.

The seasonal changes in abundance of eggs are shown in Fig. 5. Eggs were collected throughout the year, except for February and March of 1978, being most abundant in late June. The average number of eggs was very low in winter.

Table 1 shows the average number of female mosquitoes collected from human-bait for a 15 min period and their parity rate. Females fed throughout the year, with peaks in feeding activity occurring from April to June and August to November. The highest monthly averages were in June and August, a strong decrease occurring in July. Activity was minimal in December, remained very low through March. However, females frequently fed on humans on warm winter days. The parous rate of females was fairly stable through the year except for a sharp decline in March and April of 1979.

DISCUSSION AND CONCLUSIONS

Aedes albopictus is one of the commonest mosquito species in Southeast Asia and Japan, and one of the most important species from the standpoint of the transmission of pathogens. Epidemics of dengue or dengue-like fever have been reported from time to time in the Ryukyu Archipelago and in the past, *Ae. aegypti* (Linn.) was considered the principal vector with *Ae. albopictus* of secondary importance (Miyao 1931). At present, *Ae. albopictus* is the commonest and most vicious daytime biter in both urban and

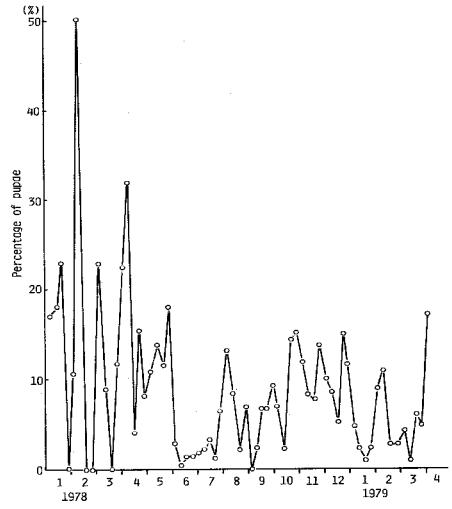

Fig. 4. Seasonal changes in percentage of pupae to all immature stages of *Ae. albocpictus* in Naha, Okinawa.

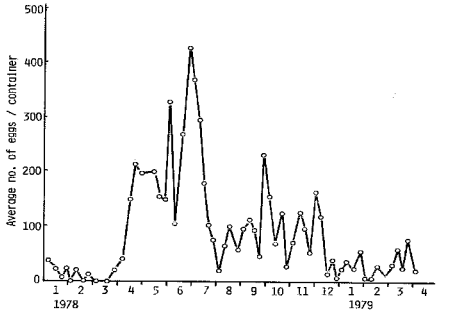

Fig. 5. Seasonal appearance of eggs of *Ae. albopictus* in Naha, Okinawa.

Table 1. Seasonal changes of *Ae. albopictus* female and parous rate.

	No. of 15 min. collections	Mosquitoes collected		No. of mosq. dissected	Parous rate (%)
		Total number	Average number		
May 1978	5	57	11.4	48	45.8
Jun. 1978	8	112	14.0	75	48.0
Jul. 1978	6	34	5.7	34	38.2
Aug. 1978	7	93	13.3	65	32.3
Sep. 1978	8	97	12.1	80	36.3
Oct. 1978	8	73	9.1	73	32.9
Nov. 1978	7	72	10.2	61	37.7
Dec. 1978	7	21	3.0	21	38.1
Jan. 1979	7	30	4.3	30	50.0
Feb. 1979	6	14	2.3	14	35.7
Mar. 1979	2	5	2.5	5	0
Apr. 1979	2	22	11.0	22	13.6

Mosquitoes were collected by daytime human-bait for 15 minutes.

rural areas in the Ryukyus but as far as we know, no reliable records of *Ae. aegypti* from Okinawajima have been found since 1938 (Saigo 1940, Bohart and Ingram 1946, Sasa et al. 1977, Tanaka et al. 1979).

In the tropics, such as Singapore city, *Ae. albopictus* breeds throughout the year. There were clearly 3 population peaks of adults during the study year, one in March, a second in June–July, and a third in November–December. These population fluctuations closely follow those of rainfall. The population peaks of larvae are found to precede those of adults by almost exactly 2 months (Ho et al. 1971).

In the temperate region, such as Japan proper, larvae of *Ae. albopictus* occur from late March to mid-September; the duration of the breeding season varying from year to year and from place to place. Usually, the greatest number of immatures is observed in July or August. In this region, *Ae. albopictus* overwinters only in the egg stage; the first adults of each year originating from this hatch (Makiya 1968, 1973, 1974; Mori and Wada 1978). Winter temperatures play an important role in the biology of *Ae. albopictus*. As far south as Kagoshima, Kyusyu, the winter temperature frequently reaches 0°C, so that larvae and adults cannot survive. In Amami-Oshima, located between Okinawajima and Kyushu, larvae are observed in winter (Takenokuma 1966) and the adult emergence can also occur in winter (Wada et al. 1976).

In the subtropical region of Okinawajima, all immature stages and parous and nulliparous females were collected every month of the year. The high density of immatures observed in July was followed by a sharp decrease through late August. This decrease may be due to density-dependent factors such as high larval numbers, starvation (Mori 1979), and chemical substances excreted by mosquito larvae under overcrowded conditions as reported by Moore and Fisher (1969), Moore and Whitacre (1972), and Ikeshoji and Mulla (1970a, b). The immature stages became very low in January and February. The number of immatures and eggs found in winter varied from year to year. Immatures and eggs tended to be more abundant in 1979 than 1978, as the winter of 1979 was warmer than that of 1978. In Okinawajima, winter temperatures are quite different from those in Japan proper. The winter average temperature from December to February is 17°C and the minimum temperature is not lower than 4°C. *Aedes albopictus* was capable of overwintering in all stages in Okinawajima. Whenever conditions are favorable during the winter, fe-

males actively seek a blood meal. Further studies on the winter biology of *Ae. albopictus* are required to determine the relationships of mosquito-borne pathogens and to conduct a successful control program of this species in the Okinawa district.

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