SEASONAL MOSQUITO FLUCTUATIONS IN DA NANG, SOUTH VIETNAM, BASED ON THREE PREVALENT SPECIES[1]

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ABSTRACT. A light trap survey was conducted in Da Nang, Vietnam for 42 weeks beginning 1 June 1969. Over 150,000 specimens were sorted and identified. The most numerous mosquitoes collected were *C. tritaeniorhynchus, A. sinensis,* and *A. vagus. C. tritaeniorhynchus* was the most prevalent mosquito throughout the study. *A. sinensis* reached peaks during September, October and November. *A. vagus* exhibited the most seasonal distribution of the three species.

INTRODUCTION

This paper is intended to provide information on the seasonal mosquito fluctuation in the coastal lowland area of Quang Nam Province, South Vietnam. Some insight may be gained concerning factors which caused localized changes in the general mosquito population. In addition, it is hoped that this presentation may benefit research personnel in South Vietnam in the future. Russell *et al.* (1963) discussed the necessity of understanding the importance of climatic effects on the mosquitoes of a region. Climatological data on rainfall, temperature, and wind velocity have been included in an attempt to correlate climatic conditions with mosquito population fluctuations.

MATERIALS AND METHODS

THE REGION. The Republic of South Vietnam is situated in the Oriental Zoogeographical Region. Ecologists have described this region as having a continuous tropical climate exhibiting little seasonal variation. Some seasonal change does occur in Vietnam. This change is caused by prevailing winds that bring about alternating wet and dry periods. These periods vary in South Vietnam from north to south and from lowland to highland.

Classically, South Vietnam has two seasons consisting of summer and winter monsoons (Bingham, 1968). The summer season begins in mid-May and lasts until September. During these months, the prevailing winds arise in the Gulf of Thailand and, in general, move over the Annam mountains to the South China Sea. This movement creates a rainy season west of the mountains and a hot semi-dry season east of the mountains and along the South China Seacoast. This relatively dry period in the northern lowlands is interrupted by occasional typhoons and severe thunderstorms which may contain winds of 65 mph.

Following a transitional period in October when climatic conditions are variable, the rainy winter monsoon begins. Warm moist air moves over the coastal lowlands and some areas receive more than 100 inches of rain during this period. Most of the rain occurs during the transitional period and early weeks of the winter season. As the rains increase in frequency and duration, the temperature gradually declines, reaching a mean of about 70° F. The rainy season is typically a period of heavy cloud cover, drizzle and fog. From

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March to May, the rain gradually diminishes in the lowlands. A transitional period in late April–May is marked by rising temperature (100° F) and general clearing.

THE STUDY AREA. The area involved in this study was near the city of Da Nang. This city, in Quang Nam Province about 500 miles north of Saigon, lies on the coast and is bordered by the South China Sea. Ecologically, Da Nang is in a coastal-deltaic zone and is bordered on the north by a mountainous land mass considered to be an outcrop of the Annam Range. The coastal-deltaic plain surrounding Da Nang is characterized by salt and brackish water mud-flats supporting mangrove-sedge communities. This area provides favorable breeding sites for many pestiferous mosquitoes.

The brackish lowlands are succeeded by the freshwater lowlands which terminate at the foothill region as one moves inland. The freshwater lowlands are characterized by sandy, clay soil which supports fern, sedge, palm and *Casuarina* along the coast. The stream margins support bamboo stands while the drier inland area is characterized by cactus, *Acanthus*, *Aegiceras*, *Lantana* and various species of *Euphrasias*. The standing water supports typical tropical floating and submerged vegetation. The shoreline habitat consists of sedges, grasses and ferns which meet the higher bamboo community. The lowlands merge with the foothill region which is covered by one canopy, broad leaf, second-growth forest with heavy undergrowth. Little virgin vegetation remains since much of the lowland coast area has been under intensive rice cultivation for many centuries.

COLLECTING METHODS. Several collecting devices and techniques were used to sample the entire mosquito population during the study. Incandescent and fluorescent light traps were used for light-attracted species and carbon dioxide and rabbit-baited traps were used to attract additional species. Larval surveys and man bite collections were conducted occasionally.

Thirteen New Jersey light traps equipped with standard 25- or 40-watt bulbs were located in the study area. Of these, three were used to plot the density data presented in this paper. These three stations were selected because they were the least disturbed. They were located approximately ¼ mile from the Da Nang River, where breeding sites ranged from swamp and freshwater "pot holes" to rice paddies and cisterns. It was felt that this area encompassed the majority of breeding habitats found in the lowlands of this particular area. The other sites were considered to be limited in their exposure to certain species or more often disturbed and yielded variable results.

The light traps were monitored daily and the total number of mosquitoes, female mosquitoes, and species were recorded. Figure 1 represents a weekly accumulation of the data from 1 June 1969 to 21 March 1970. Temperature and wind velocity was recorded weekly as averages of the daily highs and lows. Rainfall was recorded as degree of wetness derived by the following formula (Russell *et al.*, 1963):

$$\frac{\text{No. wet days x total rainfall}}{\text{No. days per week}}$$

RESULTS AND DISCUSSION

Under normal circumstances, researchers rely upon more than one method of sampling, but due to prevailing conditions, light traps in relatively secure areas provided the most consistent source of data in Vietnam in 1969. It proved unwise to conduct larval surveys, sweeps, night bite counts, or resting site surveys in the same locale routinely. Because the authors were reluctantly committed to the use of light traps, they chose to monitor only the most abundant species. Due to the general abundance of the species monitored, this sampling appeared to reflect the general population status of the area. The species studied were *Culex tritaeniorhynchus*, *Anopheles sinensis* and *Anopheles vagus*.

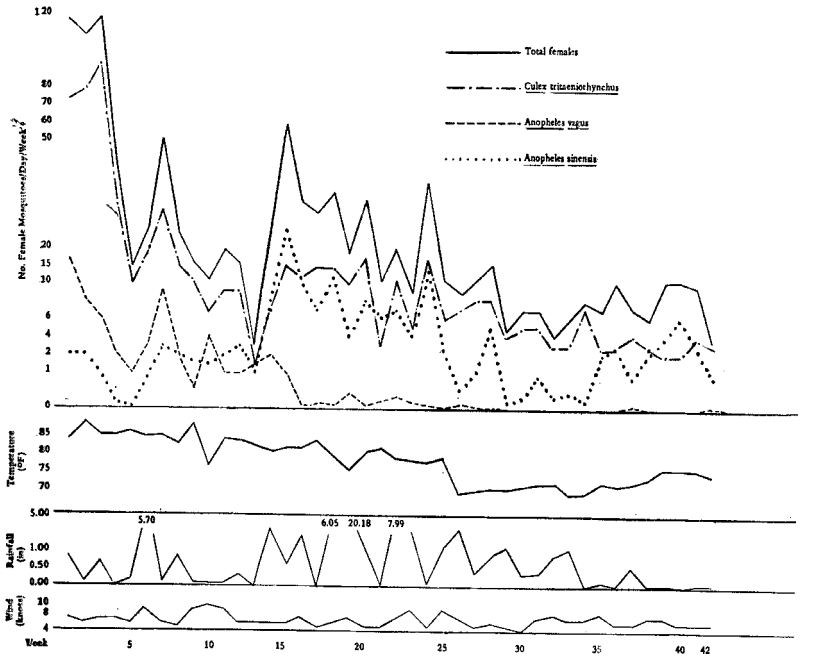

FIG. 1.—Weekly population index of female mosquitoes in Da Nang, Vietnam.

During the 42-week study (Figure 1), the most striking result was the occurrence of a high mosquito population throughout most of the year. Maximum density was attained the first week of June when the number of females averaged 116 per day per trap. The population slowly declined during the remainder of the study. The high density in June was the result of an increase in rain and temperature which created favorable breeding conditions during the last two weeks of May and the first days of June. Although the population reached its maximum in June, peaks reoccurred throughout the year. These upsurges usually occurred during or after heavy rains, but when rainfall exceeded 4 inches per day, the traps seldom yielded mosquitoes. However, the population was quick to recover from these "downpours" and foraging continued during periods when rains averaged 2 to 3 inches daily.

A period of high temperature and little rainfall produced adverse stress on the fauna. Such a period occurred during the month of August when maximum temperatures exceeded 85° for 27 days but little rain fell. During this time, the total population began to decline partly because of the disappearance of temporary breeding sites. In addition, this hot dry period was accompanied by low relative humidity. Relative humidity plays an important role in mosquito survival during times of high temperature (Boyd, 1949).

The transitional period between the summer and winter seasons began with a period of heavy, intermittent rainfall the first 12 days of October. The population rapidly adjusted to the adverse climatic conditions and continued to forage at every opportunity. It was apparent that either the existing adults were able to find harborage during the heaviest downpours or the population was replen-

ished rapidly as a result of an increase in favorable breeding habitats. As the winter progressed, the rainfall continued but the fauna declined. This decline occurred because the temperatures decreased to an average of 70–80° F and the preferred breeding sites became flooded.

It was difficult to separate any specific climatic effect as being least important when observing the mosquito ecology in Vietnam, but wind tended to have little value when viewed with respect to time. Prevailing winds consistently exceeded 5 knots. The authors noted that on many days the wind was consistently high during the day and low during the night. In general, when the wind exceeded 8 knots, a decrease in mosquito activity was noted. This did not indicate a reduction in density but a temporary delay in daily flight activity. Winds accompanied by heavy rains did cause some reduction in the adult population.

Light trap collection data obtained in 1967 and 1968 in other lowland coastal areas about 25 miles south of Da Nang indicated peak densities did not always occur early in the summer (Sholdt, 1968). The terrain in this area was primarily rice paddies, coastland and foothills. In 1967 and 1968 (unusually normal and dry monsoon seasons, respectively) maximum total density occurred in September and November, respectively. No climatic data were shown for 1967 and 1068. It is possible that continual rainfall during September and October created temporary breeding sites and refilled permanent sites which had become dry during the hot, arid months of July and August. It was noted that in 1960 some increase in activity did occur in September and October.

Although observing the general mosquito density had value, certain species trends were important to entomologists in South Vietnam. U. S. Navy entomologists have studied the *Anopheles* population in the five northern provinces for several years. Data were obtainable on lowland *Anopheles* species. However, information on upland species was extremely difficult to obtain.

It was noted that *A. sinensis* had a preference for lower atmospheric temperature. Clear, warm water with a low organic content, such as rice paddies, paddy ditches, and natural ground pools with marginal vegetation, was considered the preferred breeding habitat (Foote and Cook, 1959). *A. sinensis* reached its maximum density during the wet season. This was attributed to an increase in favorable breeding sites and a decrease in mean temperature. *A. sinensis* was most abundant during September, October and November 1969.

A. vagus was the second *Anopheles* of common occurrence in the lowlands of northern South Vietnam. This species tended to prefer higher temperatures and less rain than *A. sinensis*. Figure 1 shows that as the mean temperature dropped and the degree of wetness increased, the *A. vagus* population slowly declined and virtually disappeared during the winter monsoon season. *A. vagus* larvae preferred clear pools, fish ponds and buffalo wallows as well as rice paddies (Horsfall, 1955). It was not possible to establish optimal requirements for *A. vagus*, but in 1969 it exhibited its greatest density in early and mid summer. The mean temperature during this period was around 85° F. *A. sinensis* was present throughout the year but did not increase in number until *A. vagus* began to decline. It can be said with some assurance that *A. vagus* has a more narrow range of tolerance than *A. sinensis*.

The most prevalent mosquito throughout the study was *C. tritaeniorhynchus*, followed by *A. sinensis*. *C. tritaeniorhynchus* exhibited no seasonal variation but decreased in number slightly when natural and artificial breeding sites, such as ground pools and drainage ditches, were eliminated. Larvae were found in great numbers in the rice fields throughout the year and heavy breeding was encountered in roadside ditches and similar temporary areas near native dwellings. It bit throughout the night and readily entered dwellings seeking a blood meal. Large numbers of resting adults could be found in

sand-bagged bunkers during the day. Frequently, *C. tritaeniorhynchus* was a severe nuisance mosquito.

Other methods of sampling the mosquito population were employed to supplement the light trap data where military conditions permitted. Carbon dioxide traps, rabbit-baited traps, and man bite collections showed that *C. tritaeniorhynchus* fed on small animals if available and readily attacked man at night. Larval surveys indicated areas of heavy breeding and where possible such areas were chemically treated. Occasional larval surveys of the rice fields indicated continuous heavy *C. tritaeniorhynchus* breeding throughout the year. The additional collecting methods produced little new data but served to substantiate the light trap material.

Eight genera and more than 25 species were collected during this study (Table 1). Identification of specimens was by the Stojanovich and Scott key (1966). The 13 light traps in the Da Nang area yielded a total of 150,000 specimens during the 42-week collecting period.

TABLE 1.—Mosquitoes encountered in Da Nang, Vietnam, 1969–1970.

Genus	Species
Aedes	*albopictus*
	cancricomes
	laniger
	lineatopennis
	vexans
	vigilax
	vittatus
Aedomyia	*catasticta*
Anopheles	*aconitus*
	annularis
	jeyporiensis candidiensis
	sinensis
	stephensi
	subpictus
	vagus
Armigeres	*subalbatus*
Coquilletidia spp	
Culex	*bitaeniorhynchus*
	gelidus
	pipiens
	tritaeniorhynchus
	whitei
Mansonia	*annulata*
	annulifera
	uniformis
Tripteroides	*proximus*
Uranotaenia spp	

SUMMARY

The reliability of data obtained from New Jersey light traps has been discussed frequently. It is known that the attraction of mosquitoes to light varies from species to species (Knight, 1954); some are even repelled by light and others are more attracted at certain times during their adult life. However, light trap collection data can reflect species composition and approximate the time of year when species are sufficiently numerous to warrant the attention of vector control activities. Light trap data also provide general information which aids in understanding the epidemiology of vector-borne diseases. This study of 42 weeks did not provide the complete biology of the mosquito fauna for the area. Its primary purpose was to increase the general knowledge concerning the population trends of the most prevalent lowland species.

The combination of temperature and rainfall seemed to have a greater influence on the population than either did alone. Rains exceeding 4 inches usually reduced the flight activity. Rain associated with high wind appeared to reduce the population density, but the fauna adapted to the adverse weather conditions quickly and foraging continued during perennial rain. It is believed that there are two periods of peak mosquito activity in the northern lowland area, one occurring in early June and the other some time between September and November. Depending on the environmental conditions, one of these periods normally produces the year's highest population.

It is hoped that this presentation of data will enable future researchers in northern South Vietnam to organize better programs through increased knowledge of the behavior of some of the mosquitoes of the area. The great need for additional research in Vietnam should be

obvious. When the level of military activity is reduced to the point where attention can be given to public health programs, lack of knowledge will seriously handicap the research and medical teams.

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