CEYLON J.SCI.(BIO.SCI.) VOL.17&18,1984-85

# FURTHER OBSERVATIONS ON THE MOSQUITO FAUNA OF UDAWATTAKELE FOREST, SRI LANKA.

F.P. Amerasinghe and N.B. Munasinghe
Department of Zoology, University of Peradeniya, Sri Lanka.

**ABSTRACT**

A further study of the mosquitoes at Udawattakele Forest, Kandy was made during 1984-85, sampling the daytime resting, crepuscular-nocturnal human biting and light-trap attracted species, to supplement information on the breeding and diurnal human biting species gathered during a previous study in 1980-81.

Thirty species (7 genera) resting in the forest were collected using a battery powered suction sweeper, the dominant species being Culex pseudovishnui. This species and Cx. nigropunctatus rested mainly on leaf litter on the forest floor, while Cx.fuscocephala was collected mainly from grass or shrub/ grass patches.

Twenty five species (4 genera) were captured at human bait, with Armigeres subalbatus and Cx. pseudovishnui being the most prevalent. Biting rhythms associated with the evening crepuscular period were demonstrated in Aedes albopictus, Ar. subalbatus and Cx. pseudovishnui, but not in Ae. chrysoscuta.

Twenty five species (8 genera) were taken at CDC light traps with only Cx. pseudovishnui occurring in significant numbers.

Overall, 61 species representing 11 genera have been recorded in Udawattakele Forest from all published sources. Species diversity indices as determined in the present study, however, were low and indicated the quantitative dominance of a few species in the forest in relation to the survey methods employed.

## INTRODUCTION

Udawattekele Forest is a small, hilly patch of secondary wet zone forest, 101.6 ha. in extent, set in the heart of the hill country city of Kandy (elevation 600 m., population 100,000). Believed to have been part of the pleasure gardens of the Kings of the Kandyan Kingdom in antiquity, it is now a protected Forest Reserve and serves as a human recreational area.

There have been comparatively few studies on the mosquitoes of this human-frequented forest. Nelson et al (1971) identified seven anopheline species in the forest, during an investigation that incriminated Anopheles elegans as a vector of simian malaria, while Mendis et al (1983), described the immature stages of this same species collected in the forest. Some collections of adult and immature mosquitoes were done during the "Biosystematics of the Insects of Sri Lanka" project of the Smithsonian Institution during 1970-75 and reported in Harrison et al (1974), while a new species of Aedes collected in the forest during this same project was described by Huang(1975).

The first systematic survey of the mosquito fauna of the forest in general was carried out by Amerasinghe (1982),a study that reported on the fauna as sampled by immature collections and diurnal human biting catches during a 15 month period in 1980-81. The present paper provides information on two segments of the fauna that were not investigated in that study, namely, the daytime resting and crepuscular-nocturnal mosquito species in this forest.

## MATERIALS AND METHODS

The present study was carried out during the period March 1984 - December 1985, the forest being visited initially at fortnightly and subsequently at monthly intervals. Details of the study area and floristic characteristics of Udawattakele forest are provided in Amerasinghe (1982). Climatological data of the area during this period, collected at the Central Agricultural Research Institute, Gannoruwa, showed the weekly Mean Maximum Air Temperature = 28.93 ± 1.67°C in 1984 and 29.29 ± 1.52°C in 1985, Mean Minimum Air Temperature = 19.98 ± 1.16°C in 1984 and 20.11± 1.18 in 1985, and weekly Mean Maximum Relative Humidity (%) = 82.59 ± 5.16 in 1984 and 81.19 ± 5.19 in 1985. The total Rainfall = 2445.61 mm. during 1984 and 2387.00 mm. during 1985, slightly higher than the Mean Annual Rainfall of 2131 ± 30 mm. for the area, as recorded at the Gannoruwa station.

## FURTHER OBSERVATIONS ON THE MOSQUITO FAUNA

**Daytime Resting Collections:**

Adult mosquitoes resting on the forest floor and in low level vegetation were sampled using an "AFS Sweeper" a portable battery operated suction aspirator powered by a 12 volt D.C. motor, constructed according to the specifications of Meyer et al (1983). The air displacement of the blower was ca. 2.12 $m^3$/min., more than adequate suction for aspirating resting mosquitoes (Meyer et al, 1983). The motor and battery of the aspirator were strapped on the back of the operator, leaving the hands free to manipulate the 8 cm. diameter, 1 m. long "S-lon" nozzle which was connected to the motor by a flexible rubber hose. A total of seventy one 15-min. collections were done, each collection in an area of approximately 25m2, in four main types of ground vegetational cover found in the forest: leaf litter (no ground vegetation), shrub, shrub/grass and grass. The study was carried out during January-May 1985, with a subsequent series of collections in November-December 1985.

**Crepuscular-Nocturnal Human Bait Catches:**

Stationary human bait catches were done by 2 two-man teams collecting mosquitoes from 1 hr. before to 1 hr. after the time of official sunset of each day of collection. Mosquitoes landing/biting on the exposed face, arms and legs of the collectors were caught individually in numbered glass tubes, the catch being segregated at 10 min. intervals during this period. A single two-man team then continued catching mosquitoes for a further 5 hr., the catch being segregated at 1 hr. intervals during this period. Catch teams were changed at 1-2 hr. intervals. Four all-night (12 hr.) catches were done initially, but were later discontinued as the yield of mosquitoes declined drastically after midnight. After some preliminary experimentation to decide on the most productive sites, fixed catch stations were used throughout the study. The human baits were rotated at random over time and space to eliminate bias due to individual attractancy (Service, 1976). A total of 344 manhours (mh.) of human bait catching were done during the period March 1984 to May 1985 of which 5.33 mh. were lost due to heavy rain.

Bovid bait catches, which are generally more productive in terms of species attracted and the yield of mosquitoes per catch effort, could not be done due to administrative restrictions on the entry of domestic livestock into the Forest.

**CDC-Light Trap Catches:**

In parallel with the human bait catches, nocturnally active

mosquitoes were also sampled using two CDC-light traps operated for a 12 hr. period overnight, commencing from the time of sunset. The traps were located approximately 25 m. apart, and a similar distance from the nearest human bait team. A total of 16 trap-nights of light trapping were done during the period October 1984-May 1985.

All taxonomic identifications were made by the authors, and are based on the habitus and terminalia characteristics of adults, using modern reference keys and descriptions specific for the fauna of the Oriental and Southeast Asian Regions. The identifications have been cross checked by taxonomists at the Walter Reed Biosystematics Unit, U.S. National Museum of Natural History, Washington D.C., USA, on the basis of voucher specimens deposited at the Museum. The following generic abbreviations are used in the text: An. = Anopheles; Ae.= Aedes; Ar. = Armigeres; Coq.= Coquillettidia; Cx.= Culex; Mi.= Mimomyia; Or. = Orthopodomyia; Tp.= Tripteroides; Ur.= Uranotaenia.

## RESULTS AND DISCUSSION

### Daytime Resting Collections:

Thirty species of mosquitoes representing 7 genera were collected using the AFS Sweeper (Table 1). The most abundant species, comprising almost 53% of the total catch, was Cx. pseudovishnui, while three other species, Cx. fuscocephala (13%), Cx. nigropunctatus (6%) and Ar. subalbatus (6%), were collected regularly albeit in smaller numbers. The sex ratios of collected adults were generally biased towards the females (eg. Ae. albopictus, Cx. nigropunctatus, Cx. fuscocephala, Cx. pseudovishnui) but the reverse was seen in Cx. fuscanus and Cx. uniformis. A ratio close to unity was apparent in Ar. subalbatus, and Cx. bitaeniorhynchus, with slightly more males than females being collected in both cases. Such differences could be taken as a measure of the relative prevalences of the two sexes of these species in the forest. However, this interpretatiion would have to take into consideration factors such as the relative body size and activity levels of the two sexes, which could bias the numbers sucked into the sweeper. These factors would, of course, also cause a sampling bias at the species level, and may account for the relatively low collections of an abundant species such as Ar.subalbatus (a large, diurnally active mosquito) in relation

to smaller nocturnal species such as Cx. pseudovishnui and Cx. fuscocephala.

The data in Table 1 also show surprisingly low overall pecentages of blood-engorged (4.4%) and half-gravid (1.3%) females in these catches, compared to unfed (72.1%) and gravid (22.2%) females. These figures appear to be heavily biased by the pattern shown by Cx. pseudovishnui which constitutes 53% of the total catch, but even when this species is removed from the sample, the percentages do not change substantially (i.e. 74.7% unfed; 4.8% engorged; 2.4% half gravid and 18.1% gravid). An interpretation of the overall effect is obviously not possible, with so many species with different breeding and feeding habits constituting the total catch. However, in Cx. pseudovishnui which has not been recorded breeding in the forest (Amerasinghe, 1982), these results are suggestive of the migration of newly emerged and/or freshly oviposited unfed females into the forest from breeding areas outside. The species has been found to feed principally on birds, pigs and cattle in India (Reuben, 1971) and on bovids in Pakistan (Reisen and Boreham, 1979; Reisen et al, 1982). Wild bird hosts are abundant within Udawattakele and are probable hosts, but it is equally likely that pseudovishnui could be attracted to the abundant domestic chicken and cattle hosts available in the urban areas at the periphery of the forest and return into the forest during ovarian maturation. This would certainly explain the high numbers of fully gravid females relative to engorged or partially gravid individuals collected resting in this habitat (Table 1).

An analysis of the apparent resting habitat preferences of the four most frequently collected species is presented in Table 2, with the numbers of samples of the habitat types reflecting their relative availability - large grassy patches being much less available in this forested environment than the other vegetational types. The habitats also reflect the relative penetration of light through the canopy, with the Leaf Litter and Shrub areas being essentially under heavy shade, while the Shrub/Grass and Grass areas received at least partial sunlight during the course of the day. The results show Ar. subalbatus to be more or less evenly distributed throughout the forest, but significant resting preferences in the other 3 species: Cx. nigropunctatus and Cx. pseudovishnui rested on the heavily shaded Leaf Litter areas. Using a battery powered aspirator rather similar to the one used in the present study, Reisen (1978) and Reisen et al (1982) have shown that Cx. fuscocephala and Cx. pseudovishnui prefer outdoor (forest and agricultural fields) to indoor (house and cattle shed) resting habitats in Pakistan.

In that study, both sexes of Cx. pseudovishnui were collected in significantly greater numbers in forest than in fields, while in Cx. fuscocephala, only the males were collected in significantly greater numbers in the forest (Reisen et al, 1982).

**Crepuscular-Nocturnal Human Bait Catches:**

Twenty five mosquito species representing 4 genera were collected in this series of catches, the data being summarised in Table 3. The most prevalent species, overall, were Ar. subalbatus (51% of total catch) and Cx. pseudovishnui (33%), with regular but small catches of Ae. albopictus, Ae. chrysoscuta, Cx. bitaeniorhynchus, Cx. fuscocephala, Ae. pseudomediofasciatus and An. reidi. Of these 8 species, five (Ar. subalbatus, Ae. albopictus, Ae. chrysoscuta, Ae. pseudomediofasciatus and An. reidi) showed predominantly pre-crepuscular or crepuscular biting activity, two (Cx. pseudovishnui and Cx. bitaeniorhynchus) showed both crepuscular and later nocturnal activity, and one (Cx. fuscocephala) showed evidence of nocturnal activity (Table 3). One noteworthy point is the human biting activity of An. reidi, a recently described species (Harrison, 1973) whose biology and medical importance are unknown. Another is the absence from these evening-night catches of Ae. krombeini, a recently described member of the medically important subgenus Stegomyia of Aedes (Huang, 1975). Previous work has shown this species to breed abundantly in Udawattakele Forest but to be unattracted to diurnal human bait (Amerasinghe, 1982). On the basis of the previous and present results, it can be concluded that the species is not readily attracted to human hosts and thus of little medical importance.

The crepuscular biting rhythms of 4 species, analysed in relation to the 10 min. time-segregated catches carried out in the period from 1 hr. before to 1 hr. after official sunset, are presented in Figures 1 and 2. The activity in two Aedes species, as illustrated in Figure 1, shows a steady decrease in diurnal biting with the approach of sunset. However, while the decrease continues uninterruptedly to an eventual cessation of activity shortly after sunset in Ae. chrysoscuta, there is a small but distinct increase in biting around sunset in Ae. albopictus, with the peak occurring in the 10 min. period immediately before sunset time. Ae. albopictus is well known to be a diurnal human biting species, showing peak activity in mid-late afternoon in Udawattakele Forest (Amerasinghe, 1982). It is interesting to note that the present observation of a secondary peak of activity associated with twilight has not apparently been reported previously in the literature.

Armigeres subalbatus is known to be primarily a

crepuscular biter (Aslamkhan and Salman, 1969; Wada, 1969) but has been shown to be diurnally active as well, in Udawattakele Forest (Amerasinghe, 1982). A continuation of diurnal activity into a crepuscular peak (lasting about 20 min. pre-sunset time) is evident in this species, followed by a rapid decline and virtual cessation about 1 hr. after sunset (Figure 2). In Cx. pseudovishnui, by contrast, diurnal biting even under the reduced light conditions of the forest canopy is minimal (Amerasinghe, 1982). A sharp rise in biting activity is observed with the approach of sunset, with a peak 10-20 min. later. Although there is a slight decline thereafter, biting continues well into the night (Figure 2). Previous observations in Pakistan show the biting rhythm of Cx. pseudovishnui to be essentially bimodal, with a major crepuscular peak, followed by a secondary peak towards dawn (Reisen et al, 1976; Reisen and Aslamkhan, 1978).

Phenomena such as biting rhythms are usually studied in relation to the position of the sun, since the onset or cessation of biting activity in many species appears to be initiated by changes in illumination and thus frequently correlated with times of sunrise and sunset (Service, 1976). With the rising and setting of the sun varying seasonally (even at the equator) and over different lattitudes, clock times become irrelevant, because meaningful comparisons over time and space cannot be made. It is important, therefore that bait catch times be adjusted in relation to exact sunrise or sunset times (Lumsden, 1952) as has been done in the present work. In this context, a useful standardised unit of measurement valid for seasonal and lattitudinal comparisons is the Nielsen Crep Unit, which is defined as the interval between official sunset (sun angle 0 deg. 50' below horizon) and the end of civil twilight (sun angle 6 deg. 00' below horizon) (Nielson, 1961, 1963; Haddow et al, 1968; Service, 1976). In relation to the 20-23 min. duration of civil twilight in the 6-10 deg. N Latitudinal location of Sri Lanka, the activity peaks discussed above correspond to crep ranges of -0.5 to 0 for Ae.albopictus, -1 to 0 for Ar. subalbatus and +0.43 to +1 for Cx. pseudovishnui biting under the forest canopy.

**CDC-Light Trap Catches:**

The results of 16 trap-nights of light trapping are summarised in Table 4. Twenty five species of mosquitoes representing 8 genera were attracted to these traps, with Cx. pseudovishnui being the predominant species accounting for nearly 61% of the total catch. As in the case of the AFS Sweeper collections, the light trap data show that unfed females comprised the major segment (80%) of the total catch of this species.

Overall, the performance of the traps in the forest was disappointing from a quantitative viewpoint, with a total of only 133 adults of all species (8.3 per trap-night or 0.69 per trap hour) being collected. This compares rather unfavourably with all-species rates of 8.26 females per man-hr. (total catch) or 14.80 per man-hr. (crepuscular catch) at human bait and 49.69 adults per man-hr. using the AFS Sweeper. Aslamkhan and Salman (1969), and Reisen (1978) also report poor yields using light traps in Pakistan, compared to other survey methods such as bait catches and resting collections. Qualitatively, however, the CDC traps were a useful faunal survey tool in the present study, with several species (eg. An. barbirostris, An. varuna, Mi. luzonensis, Coq. crassipes, Ur. srilankensis) not recorded by other methods being collected by the traps.

**Species Diversity and Faunal Checklist:**

The numbers of species and individuals collected by different survey methods at Udawattakele during a previous survey (Amerasinghe, 1982) and the present study are summarised in Table 5. A measure of the ecological diversity of the fauna is provided by the 'Shannon-Weaver Index (Shannon and Weaver, 1963), which reflects the apportionment of individuals among species. The overall index is low (Table 5) indicating the dominance of the fauna by relatively large numbers of a few species. For instance, the diurnal and nocturnal bait catches which showed the lowest diversity values, were dominaed by 3 prevalent man biting species: Ar. subalbatus, Cx.pseudovishnui and Ae. albopictus (Amerasinghe, 1982, and present study). The former two species, together with Cx. fuscocephala and Cx. nigropunctatus were the most prevalent in the daytime resting collections, while Cx. pseudovishnui alone predominated at the light trap catches. Larval collections were dominated by Cx. uniformis and Ae. krombeini (Amerasinghe, 1982). Although a large number of other species were collected by these methods, their quantitative contribution was minimal, thus resulting in low diversity values.

Considering all published reports, 61 species have been recorded from Udawattakele Forest to date. The genus Culex with 18 species (29.5%) and Aedes with 17 species (27.9%) dominate the fauna, followed by Anopheles with 12 species (19.7%). Eight other genera collectively contribute the remaining 14 species (22.9%) recorded from the forest. A checklist of these species together with the methods of collection at which individual species have been collected and the literature references relating to them are provided in Appendix I, as a step towards indexing the localised distributions of mosquito species in the context of their overall distributional patterns on the island.

ACKNOWLEDGEMENT

We wish to thank Mr. V.R. Nanayakkara, Conservator of Forests , for permission to work in Udawattakele Forest, and the staff of the Range Forest Office, Kandy, for their cooperation. We also gratefully acknowledge the technical assistance of Mr. N.K. Jayawardena and field assistance of Messrs. H.M. Gunaratna Banda, D.B. Ratnayake and K.A.W. Samarakoon, as well as others who assisted in the human bait catches. This work was done as part of a wider investigation of mosquito vector ecology in Kandy, for which financial assistance was received from the U.S. National Academy of Sciences through a grant from USAID.

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**TABLE 1**

**DAYTIME RESTING MOSQUITOES IN UDAWATTAKELE FOREST**

| SPECIES | NO. OF ADULTS (% of TOTAL) | M.F. RATIO* | TROPHIC STATUS (F)+ UF | BF | HG | FG |
|---|---|---|---|---|---|---|
| An. aitkenii | 01 (0.11) | (1:0) | - | - | - | - |
| An. maculatus | 01 (0.11) | (1:0) | - | - | - | - |
| An. tessellatus | 02 (0.23) | (1:1) | 01 | - | - | - |
| An. vagus | 01 (0.11) | (0:1) | - | - | - | 01 |
| Tp. affinis | 07 (0.79) | (5:2) | 01 | - | - | 01 |
| Ur. campestris | 02 (0.23) | (0:2) | 02 | - | - | - |
| Ur. nivipleura | 07 (0.79) | (4:3) | 02 | - | - | 01 |
| Ur. (Ura) sp. | 04 (0.45) | (3:1) | 01 | - | - | - |
| Or. anopheloides | 02 (0.23) | (2:0) | - | - | - | - |
| Ae. macdougalli | 02 (0.23) | (0:2) | 02 | - | - | - |
| Ae. albopictus | 29 (3.29) | 1:1.9 | 17 | 01 | - | 01 |
| Ae. jamesi | 03 (0.34) | (0:3) | 02 | - | - | 01 |
| Ae. pipersalatus | 01 (0.11) | (0:1) | 01 | - | - | - |
| Ae. chrysoscuta | 04 (0.45) | (0:4) | 04 | - | - | - |
| Ae. pseudomediofasciatus | 02 (0.23) | (0:2) | 02 | - | - | - |
| Ar. aureolineatus | 02 (0.23) | (1:1) | 01 | - | - | - |
| Ar. subalbatus | 54 (6.12) | 1.1:1 | 18 | 06 | 01 | 01 |
| Cx. infantulus | 01 (0.11) | (1:0) | - | - | - | - |
| Cx. uniformis | 28 (3.17) | 1.3:1 | 05 | 03 | 02 | 02 |
| Cx. nigropunctatus | 58 (6.39) | 1:2.5 | 36 | - | - | 04 |
| Cx. pallidothorax | 09 (1.02) | (6:3) | 03 | - | - | - |
| Cx. fuscanus | 23 (2.61) | 2.8:1 | 06 | - | - | - |
| Cx. fuscocephala | 119 (13.49) | 1:2:2 | 57 | - | - | 25 |
| Cx. quinquefasciatus | 07(0.79) | (2:5) | 02 | - | 03 | - |
| Cx. bitaeniorhynchus | 17 (1.93) | 1.1:1 | 03 | 01 | - | 04 |
| Cx. gelidus | 08 (0.91) | (2:6) | 06 | - | - | - |
| Cx. whitmorei | 06 (0.68) | (1:5) | 03 | - | - | 02 |
| Cx. pseudovishnui | 467 (52.95) | 1:1.4 | 188 | 11 | 01 | 70 |
| Cx. tritaeniorhynchus | 15 (1.70) | 1:4 | 10 | 01 | - | 01 |
| Cx. mimulus | 02 (0.23) | (0:2) | 01 | - | - | 01 |
| TOTAL | 882 (99.99) | 1:1.4 | 374 | 23 | 07 | 115 |

* Figures in brackets refer to actual numbers of males (M) and females (F)

\+ UF = unfed; BF = blood fed; HG = half gravid; FG = fully gravid.

TABLE 2

RESTING HABITS OF FOUR MOSQUITO SPECIES IN UDAWATTAKELE FOREST*

| | H A B I T A T | | | | ANOVA+ |
|---|---|---|---|---|---|
| | LEAF LITTER | SHRUB | SHRUB/ GRASS | GRASS | |
| No. of samples | 21 | 19 | 21 | 10 | |
| Ar. subalbatus | 0.39a | 0.53a | 0.64a | 0.60a | Not Sig. |
| Cx. nigropunctatus | 1.17a | 0.37b | 0.27b | 0.15b | $P < 0.025$ |
| Cx. fuscocephala | 0.54a | 0.50a | 1.88b | 3.08b | $P < 0.001$ |
| Cx. pseudovishnui | 12.74a | 1.02b | 2.73b | 1.35b | $P < 0.001$ |

* The values presented are geometric means of the no. of adults/15 min. collection sample.

\+ Single classification Analysis of Variance (ANOVA) using the square root transformation to normalise data (Sokal and Rohlf, 1969). Row means followed by the same letter are not significantly different ($P < 0.05$) using the Mann-Whitney U Test.

TABLE 3

FEMALE MOSQUITOES COLLECTED LANDING/BITING AT CREPUSCULAR-NOCTURNAL HUMAN BAIT CATCHES

| SPECIES | TOTAL CATCH+ | | CREPUSCULAR CATCH* | |
|---|---|---|---|---|
| | NO.(%) | MAN-HR. RATE | NO.(%) | MAN-HR. RATE |
| An. aitkenii gr. | 02 (0.07) | | 02 | |
| An. interruptus | 03 (0.11) | | 03 | |
| An. reidi | 29 (1.04) | 0.08 | 25 (86.21) | 0.16 |
| An. aconitus | 06 (0.21) | | 02 | |
| An. maculatus | 04 (0.14) | | 03 | |
| An. vagus | 02 (0.07) | | - | |
| Ae. aureostriatus | 07 (0.25) | | 07 | |
| Ae. macdougalli | 01 (0.04) | | 01 | |
| Ae. annulirostris | 02 (0.07) | | 02 | |
| Ae. albopictus | 107 (3.82) | 0.32 | 96 (89.72) | 0.62 |
| Ae. novalbopictus | 04 (0.14) | | 04 | |
| Ae. mediopunctatus | 01 (0.04) | | 04 | |
| Ae. chrysoscuta | 81 (2.89) | 0.24 | 80 (98.77) | 0.52 |
| Ae. pseudomediofasciatus | 29 (1.04) | 0.08 | 29 (100) | 0.19 |
| Ae. srilankensis | 01 (0.04) | | 01 | |
| Ar. aureolineatus | 03 (0.11) | | 03 | |
| Ar. subalbatus | 1430(51.11) | 4.22 | 1399(97.83) | 9.04 |
| Cx. fuscocephala | 35 (1.25) | 0.10 | 09 (25.71) | 0.06 |
| Cx. quinquefasciatus | 04 (0.14) | | 02 | |
| Cx. bitaeniorhynchus | 79 (2.82) | 0.23 | 38(48.10) | 0.24 |
| Cx. infula | 17 (0.61) | | 10 | |
| Cx. gelidus | 12 (0.43) | | 10 | |
| Cx. whitmorei | 03 (0.11) | | 03 | |
| Cx. pseudovishnui | 929 (33.20) | 2.74 | 555(59.74) | 3.59 |
| Cx. tritaeniorhynchus | 07 (0.25) | | 05 | |
| TOTAL | 2798 (100) | 8.26 | 2290(81.84) | 14.80 |

\+ 338.67 mh., from 1 hr. before to 6 hr. after sunset.
(%) refers to percentage of total catch of all species together.

* 154.67 mh., from 1 hr. before to 1 hr. after sunset.
(%) refers to percentage of total catch of each species.

TABLE 4

MOSQUITO SPECIES COLLECTED AT CDC LIGHT TRAPS IN UDAWATTAKELE FOREST

| SPECIES | NO. OF ADULTS (% OF TOTAL) | M.F. RATIO* | TROPHIC STATUS (F)+ UF | BF | HG | FG |
|---|---|---|---|---|---|---|
| An. barbirostris | 01 (0.75) | (0:1) | - | - | - | 01 |
| An. reidi | 01 (0.75) | (1:0) | - | - | - | - |
| An. tessellatus | 01 (0.75) | (0:1) | - | 01 | - | - |
| An. varuna | 01 (0.75) | (0:1) | 01 | - | - | - |
| Mi. luzonensis | 03 (2.26) | (0:3) | 02 | - | - | 01 |
| Coq. crassipes | 01 (0.75) | (0:1) | 01 | - | - | - |
| Ur. campestris | 03 (2.26) | (1:2) | 02 | - | - | - |
| Ur. nivipleura | 01 (0.75) | (0:1) | 01 | - | - | - |
| Ur. srilankensis | 03 (2.26) | (2:1) | 01 | - | - | - |
| Or. anopheliodes | 01 (0.75) | (0:1) | 01 | - | - | - |
| Ae. chrysoscuta | 03 (2.26) | (0:3) | 03 | - | - | - |
| Ae. jamesi | 01 (0.75) | (0:1) | - | - | - | 01 |
| Ae. pipersalatus | 01 (0.75) | (0:1) | - | - | - | 01 |
| Ae. pseudomediofasciatus | 01 (0.75) | (1:0) | - | - | - | - |
| Ae. srilankensis | 02 (1.50) | (0:2) | 02 | - | - | - |
| Ar. subalbatus | 03 (2.26) | (1:2) | 01 | - | - | 01 |
| Cx. fuscanus | 02 (1.5) | (1:1) | 01 | - | - | - |
| Cx. nigropunctatus | 06 (4.51) | (1:5) | 04 | - | - | 01 |
| Cx. uniformis | 04 (3.01) | (4:0) | - | - | - | - |
| Cx. fuscocephala | 06 (4.51) | (3:3) | 02 | - | - | 01 |
| Cx. bitaeniorhynchus | 04 (3.01) | (1:3) | 02 | - | - | 01 |
| Cx. infula | 01 (0.75) | (0:1) | 01 | - | - | - |
| Cx. whitmorei | 01 (0.75) | (0:1) | - | - | - | 01 |
| Cx. pseudovishnui | 81 (60.90) | 1:4.78 | 65 | 01 | - | 01 |
| Cx. mimulus | 01 (0.75) | (0:1) | 01 | - | - | - |
| TOTAL | 133 (99.99) | 1:3.43 | 91 | 02 | - | 10 |

* Figures in brackets refer to actual numbers of males (M) and females (F).

\+ UF = unfed; BF = blood fed; HG = half gravid; FG = fully gravid.

**TABLE 5**

**MOSQUITO SPECIES DIVERSITY (SHANNON-WEAVER INDEX) BY DIFFERENT SAMPLING METHODS AT UDAWATTAKELE FOREST**

| | LC* | DB* | NB | RC | LT | TOTAL |
|---|---|---|---|---|---|---|
| NO. OF SPECIES | 17 | 21 | 25 | 32 | 25 | 60 |
| NO. OF SPECIMENS | 1914 | 1598 | 2798 | 882 | 133 | 7325 |
| DIVERSITY | 0.95 | 0.60 | 0.59 | 0.79 | 0.79 | 0.96 |

* Surveyed in 1980-81 (Amerasinghe, 1982)

LC = Larval Collections; DB = Diurnal Human Bait catches;
NB = Nocturnal Human Bait Catches; RC = Resting catches;
LT = Light Traps)

## APPENDIX I

## MOSQUITO SPECIES RECORDED AT UDAWATTAKELE FOREST, SRI LANKA.

(LC = Larval Collections; BC = Bait Catches: RC = Resting Catches; LT = Light Traps)

| SPECIES | COLLECTION METHOD | | | | REF.* |
|---|---|---|---|---|---|
| | LC | BC | RC | LT | |
| Anopheles (Anopheles) aitkenii James 1903 | - | x | x | - | 1,6 |
| An. (Ano.) barbirostris Van der Wulp 1884 | x | x | - | x | 4,5,6 |
| An. (Ano.) interruptus Puri 1929 | - | x | - | - | 6 |
| An.(Ano.) peditaeniatus (Leicester) 1908 | x | x | - | - | 1,5 |
| An. (Ano.) reidi Harrison 1973 | - | x | - | x | 6 |
| An. (Cellia) aconitus Donitz 1902 | - | x | - | - | 6 |
| An. (Cel.) elegans (James) 1903 | x | x | - | - | 1,4,5 |
| An. (Cel.) jamesii Theobald 1901 | - | x | - | - | 5 |
| An. (Cel.) maculatus Theobald 1901 | x | x | x | - | 5,6 |
| An. (Cel.) tessellatus Theobald 1901 | - | x | x | x | 5,6 |
| An. (Cel.) vagus Donitz 1902 | x | x | x | - | 5,6 |
| An. (Cel.) varuna Iyengar 1924 | - | - | - | x | 6 |
| Toxorhynchites (Toxorhynchites) splendens (Weidemann)1819 | x | - | - | - | 1 |
| Tripteroides (Rachionotomyia) affinis (Edwards) 1913 | x | - | x | - | 1,6 |
| Tp. (Rac.) ceylonensis Theobald 1905 (= local form of "aranoides" Theobald, 1901). | x | - | - | - | 1 |
| Mimomyia (Etorleptiomyia) luzonensis (Ludlow) 1905 | - | - | - | x | 6 |
| Coquillettidia (Coquillettidia) crassipes (Van der Wulp) 1881 | - | - | - | x | 6 |
| Uranotaenia (Uranotaenia) campestris Leicester 1908 | - | - | x | x | 6 |
| Ur. (Pseudoficalbia) nivipleura Leicester 1908 | - | - | x | x | 6 |
| Ur. (Pfc.) srilankensis Peyton 1974 | - | - | - | x | 6 |
| Ur. (Pfc.) sp. | - | - | x | - | 6 |
| Orthopodomyia anopheliodes (Giles) 1903 | x | - | x | x | 1,6 |
| Heizmannia (Heizmannia) greenii (Theobald) 1905 | x | x | - | - | 1,6 |
| Hz. (Hez.) sp. | - | x | - | - | 1 |

APPENDIX I CONTD.

| SPECIES | COLLECTION METHOD | | | | REF.* |
|---|---|---|---|---|---|
| | LC | BC | RC | LT | |
| Aedes (Finlaya) sp. niveus sub-gp. | x | - | - | - | 1 |
| Ae. (Fin.) aureostriatus (Doleschall) 1857 | x | x | x | - | 1,6 |
| Ae. (Fin.) gubernatoris (Giles) 1901 | - | x | - | - | 1 |
| Ae. (Fin.) macdougalli Edwards 1922 | - | x | x | - | 6 |
| Ae. (Fin.) pseudotaeniatus (Giles) 1901 | - | x | - | - | 1 |
| Ae. (Christophersiomyia) annulirostris | - | x | - | - | 1,6 |
| Ae. Stegomyia) aegypti (Linnaeus) 1762 | - | x | - | - | 1 |
| Ae. (Stg.) albopictus (Skuse) 1894 | x | x | x | - | 1,2,3,6 |
| Ae. (Stg.) novalbopictus Barraud 1931 | - | x | x | - | 1,6 |
| Ae. (Stg.) krombeini Huang 1975 | x | x | - | - | 1,3 |
| Ae. (Stg.) mediopunctatus (Theobald) 1905 | x | x | - | - | 1,3,6 |
| Ae. (Aedimorphus) jamesi (Edwards) 1914 | - | x | x | x | 1,6 |
| Ae. (Adm.) pipersalatus (Giles) 1902 | - | - | x | x | 6 |
| Ae. (Adm.) vittatus (Bigot) 1861 | - | x | - | - | 1 |
| Ae. (Paraedes) chrysoscuta (Theobald) 1910 | - | x | x | x | 1,6 |
| Ae. (Verrallina) pseudomediofasciatus (Theobald) 1910 | x | x | x | x | 1,6 |
| Ae. (Ver.) srilankensis Reinert 1977 | - | x | - | x | 6 |
| Armigeres (Armigeres) aureolineatus (Leicester) 1908 | - | x | x | - | 6 |
| Ar. (Arm.) subalbatus (Coquillett) 1898 | x | x | x | x | 1,6 |
| Culex (Lutzia) fuscanus Wiedemann 1820 | - | - | x | x | 1,6 |
| Cx. (Eumelanomyia) brevipalpis (Giles) 1902 | x | - | - | - | 1 |
| Cx. (Lophoceromyia) infantulus Edwards 1922 | - | - | x | - | 6 |
| Cx. (Lop.) lasiopalpis Sirivanakarn 1977 | - | - | x | - | 1 |
| Cx. (Lop.) uniformis (Theobald) 1905 | x | - | x | x | 1,6 |
| Cx. (Lop.) wardi Sirivanakarn 1977 | - | - | x | - | 1 |
| Cx. (Culiciomyia) nigropunctatus Edwards 1926 | - | - | x | x | 1,6 |
| Cx. (Cul.) pallidothorax Theobald 1905 | - | - | x | - | 1,6 |
| Cx. (Culex) fuscocephala Theobald 1907 | x | x | x | x | 1,6 |
| Cx. (Cux.) quinquefasciatus Say 1823 | - | x | x | - | 6 |
| Cx. (Cux.) bitaeniorhynchus Giles 1901 | - | x | x | x | 6 |
| Cx. (Cux.) Infula Theobald 1901 | - | x | - | x | 6 |
| Cx. (Cux.) sitiens gp. Edwards 1932 | - | x | - | - | 1 |
| Cx. (Cux.) whitmorei (Giles) 1904 | - | x | x | x | 6 |
| Cx. (Cux.) gelidus Theobald 1901 | - | x | x | - | 6 |
| Cx. (Cux.) pseudovishnui Colless 1957 | - | x | x | x | 1,6 |
| Cx. (Cux.) tritaeniorhynchus Giles 1901 | - | x | x | - | 6 |
| Cx. (Cux.) mimulus Edwards 1915 | x | - | x | x | 1,6 |

* 1= Amerasinghe (1982); 2 = Harrison et al (1974): 3 = Huang (1975);
4 = Mendis et al (1983); 5 = Nelson et al (1971); 6 = Present Study

## LEGENDS FOR FIGURES

FIGURE 1: Histogram of the crepuscular activity rhythm of Ae. chrysoscuta (hatched bars) and Ae. albopictus (open bars) at human bait. Units on the x-axis how time before (-) and after (+) sunset, and on the y-axis show the geometric mean (William's Mean) of the number of females per 10 min. catch period expressed as a percentage.

FIGURE 2: Histogram of the crepuscular activity rhythm of Ar. subalbatus (hatched bars) and Cx. pseudovishnui (open bars) at human bait. Units on the x-axis show time before (-) and after (+) sunset, and on the y-axis show the geometric mean (William's Mean) of the number of females per 10 min. catch period expressed as a percentage.

FIGURE 1: CREPUSCULAR ACTIVITY OF AE.ALBOPICTUS AND AE.CHRYSOSCUTA

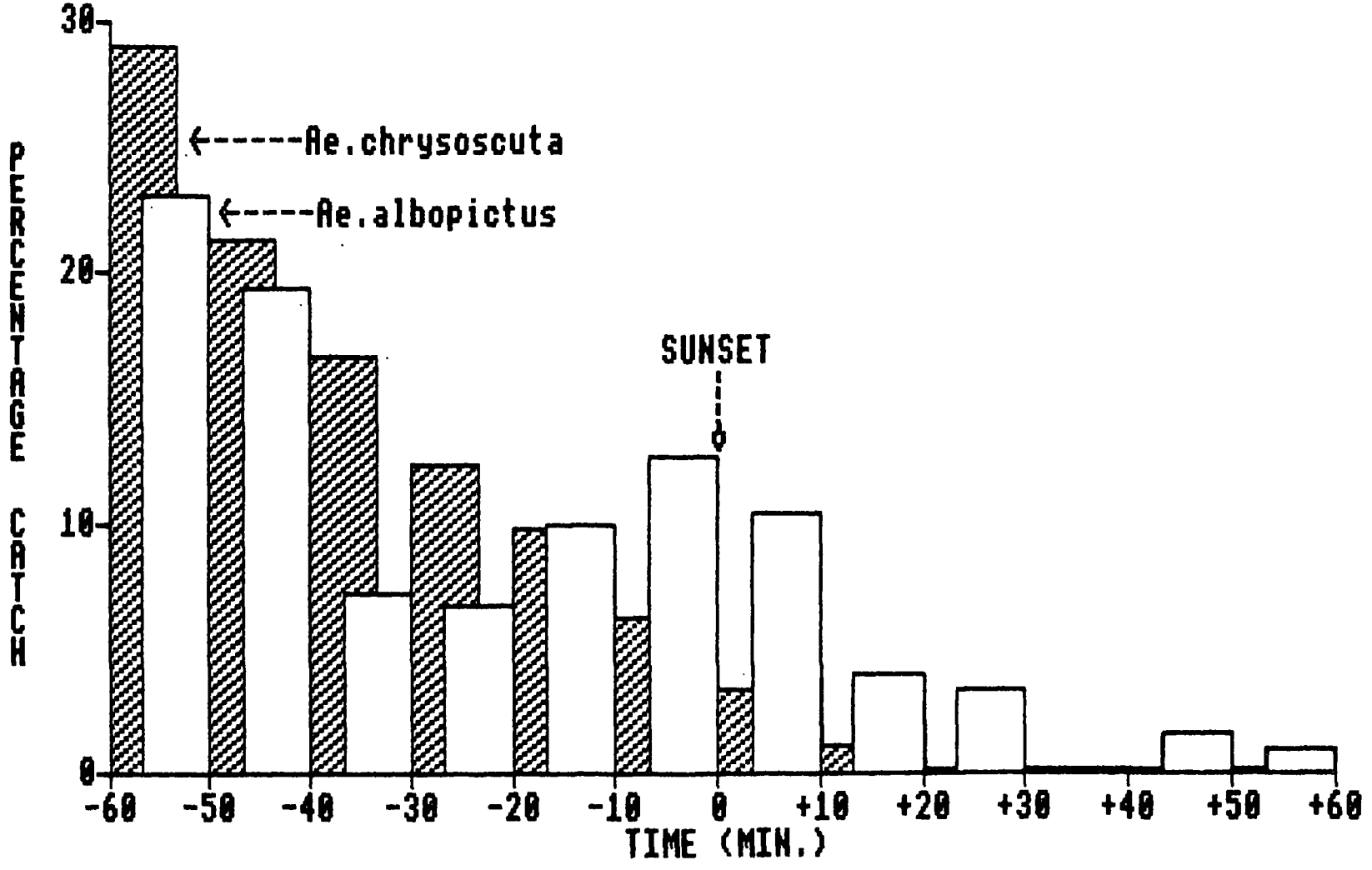

FIGURE 2: CREPUSCULAR ACTIVITY OF AR.SUBALBATUS AND CX.PSEUDOVISHNUI