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REPORT ON SURVEY OF FERAL AND DOMESTIC POPULATIONS OF AEDES (ST.) AEGYPTI AND SOME OTHER STEGOMYA SPECIES IN UGANDA AND KENYA

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A. PURPOSE OF THE TRIP

1. The Mosquito Biology Unit of ICIPE is conducting basic research on ecology of Aedes aegypti in Kenya preliminary to a field trial for genetic control of this mosquito. In this respect mating and biting behaviour of Ae. aegypti are certainly two of the most important specific problems which should be analyzed in both field and the laboratory. Experiments which are in progress at the Vector Biology Laboratory, University of Notre Dame show that these behavioural phenomena can vary from population to population even in the same geographical area. VBL as the WHO International Reference Center for Aedes has about 60 "strains" of Ae. aegypti collected from various parts of the world. Some of them are fresh, some have been cultivated in this laboratory for several years. The first objective of this trip was to obtain freshly collected strains of Aedes aegypti for genetic and behavioral analysis in the laboratory.

2. Haddow (1945) and Lumsden (1951) reported that Ae. aegypti is not anthropophilic in Bwamba County, Uganda, in the area where yellow fever repeatedly occurred since 1935 (Sawyer and Whitman 1936). Similar observation on a non-anthropophilic population of Ae. aegypti was made by Garnham et al. (1946) in the Kaimosi Forest (SW Kenya). Ae. aegypti was scattered throughout the forest but rarely found in the native villages. From 185 huts searched for breeding in two years, 1943 and 1944 larvae were found only once. Breeding inside houses was not recorded. Our second objective on this trip was to study diversity of breeding habitats of Ae. aegypti in Uganda and Kenya.

3. Since these populations were needed for further analysis and behavioral studies in the laboratory it was our aim to bring reasonably large samples of live larvae of Ae. aegypti from various places from Uganda and Kenya to Notre Dame for further colonization.

4. Studies at MBU by Drs. Hausermann and Fanara show that there are three different populations of Ae. aegypti in the Rabai area, 16 miles North of Mombasa, Kenya. These are: 1. domestic, 2. peridomestic, 3. feral. We have found in our laboratory studies that the feral Ae. aegypti does not eneter our olfactometer trap chambers as readily as the domestic one. This might indicate that the representatives of the feral populations are exophilic in their biting haviour. Six special baited traps made of clear plastic were constructed at VBL, UND and shipped to Mombasa to test the local populations of Ae. aegypti for this phenomenon.

5. I spent considerable time on discussion of various aspects of population dynamics with the three scientists (Drs. Hausermann, McDonald and Fanara) of the Mosquito Biology Unit at Mombasa.

B. FIELD STUDIES IN UGANDA

The aim of this six day trip (from 23 August to 28 August 1972) was to study the distribution of Ae. aegypti in domestic, peridomestic and feral biotopes and to collect live mosquitoes for further studies in the laboratory.

Bunono automobile scrap-heap located on Entebbe pennisula was the only place where Ae. aegypti was observed biting man in Uganda (McClelland, 1959). However, in the total catch of more than 9,000 specimens of various mosquito species Ae. aegypti represented only 2.5%. To our knowledge, there is no other reference on man biting population of Ae. aegypti from Uganda. Apparently Ae. aegypti in Uganda has a different biting behavior from that found in Tanzania (Lumsden, 195, Trpis et al. 1971) and Kenya (Teesdale, 1955). Ae. aegypti breeds in Tanzania predominantly in peridomestic and domestic habitats but outdoors. Little breeding can be found either in forests or indoors (Trpis, 1970). On the Kenya Coast, Ae. aegypti breeds at least in some areas equally domestic, peridomestic and forest sites (Teesdale, 1955, Hausermann, 1972, Fanara, 1972).

1. Entebbe

I arrived at Entebbe on 23 August as a guest of the Director of the East African Virus Research Institute, Dr. G. W. Kafuko to whom I express much gratitude for arrangement of my trip to Bwamba, Masaka, Lyatonde, Mbarara and vicinity of Entebbe. I am also thankful to Dr. L.G. Mukwaya, Mr. S.D.K. Sempala and Mr. Y. Ssenkubuge for their wonderful company, help at the field work and discussions on various aspects of ecology of Stegomyia and Toxorhynchites mosquitoes in Uganda.

First two days (23-24 August) I spent at the East African Virus Research Institute at Entebbe and made two short trips, first to Zika Forest and secondly to Pemba Forest, Kampala and Bwayise.

a. Zika Forest is part of the extensive lake-shore forest about 10 km from Entebbe. Many forest mosquito species occur in Zika Forest. Perhaps the most abundant is Ae. (St.) africanus known as a vector of yellow fever and Zika virus among monkeys. The less known Zika virus shares the same serological group as YF virus as well as the same host-vector system (forest monkeys - Aedes africanus). The scientists of the EAVRI have isolated this virus more than 30 times in Entebbe area. They believe that the immunity to Zika virus appears to reduce the level of viremia against VF in monkeys. The combine immunity to several of the group B viruses may produce immunity against YF.

b. Mpanga Forest is located about 40 km from Kampala on Masaka road about 16 km North of Lake Victoria. Forest Reserve of 450 hectares is in altitude 1,160 m. Extensive studies on ecology of forest mosquitoes were done here by EAVRI, Drs. Haddow, Gillett, Corbet and others in the late fifties. It is permanently flooded in lower parts having a character of swamp. The forest is thick in both swamp and slopes (Fig. 2).

We collected Ae. simpsoni from Dracaena and banana axils at the edge of the forest. A steel tower with several platforms for catching mosquitoes above the forest canopy (about 40 m) was built here by EARVI and later transfered to Zika Forest.

c. Kampala. A large automobile dump (Fig. 3), located in a suburban area of Kompala city was searched for breeding of Ae. aegypti and other species. Larvae of Ae. aegypti were collected from a steel box (100 x 60 x 120 cm) and live larvae sampled for further rearing and anlysis. Culex pipiens fatigans was more abundant than Ae. aegypti here.

d. Bwayise. Located at Kampala is a locality where the population of Ae. simpsoni is zoophilic. There is extensive breeding of Ae. Simpsoni in colocasia plant axils (Fig. 4). We have collected many larvae from axils (Fig. 5); however, no eggs were received from the females, which are strictly eurygamous (Mukwaya, 1971).

2. Trip to Fort Portal, Bwamba, Mbarara, Lyatonde and Masaka.

After two days work in Entebe area a round-trip of three days (from 25 to 27 August) was made through the SW part of Uganda. I was accompanied on this trip by Dr. L.G. Mukwaya, Mr. Y. Ssenkubuge and a driver. The service of laboratory technition, driver and VW-Combi vehicle was provided by the EAVRI.

Survey Methods

The short time available did not allow us to make detailed survey. In various physiographical areas the nature of the problem dictated survey predominantly in villages. Search for breeding of Ae. aegypti larvae was done in villages around human habitations, in plant axils, treeholes and inside houses in containers with drinking water such as water pots, buckets, metal drums etc. From all places where breeding of Ae. aegypti was found a sample of live larvae was collected for laboratory colonization and further studies.

a. Fort Portal. The trip from Entebbe to Fort Portal on 25 August lasted for 8 hours on not a quite good roads. Search for Ae. aegypti was made in and around Fort Portal. No breeding of Ae. aegypti was found in this area. Ae. simpsoni larvae were collected from colocasia axils in Nyakasula Village which is located close to foothills of the Ruwenzori Mountains. No breeding of Ae. simpsoni was found on slopes of the Ruwenzori Mountains. About 0.5 hectare pineapple plantation located on slopes of the Ruwenzori Mountains was searched for mosquito larva on 26 August. There was water in axils but no larvae (elevation of 1,500m).

b. Semlike basin and Bwamba area. The vegetation on N slopes of the Ruwenzori Mountains is thick, impossible for man to pass through. Black and white colobus (Colobus polykomos) monkeys are abundant in this area. Bwamba is a small area in the extreme west of Uganda, lying between the Ruwenzori

Mountains and the Semliki River. Yellow fever virus was isolated from a human case and from Ae. simpsoni in early forties. Haddow (1945) claimed that Ae. aegypti is non-anthropophilic in this area. However, it is not known whether or not Ae. aegypti is zoophilic here. It might be autogenous as well.

We have collected Ae. aegypti larvae from various manmade containers such as sink-water traps, motor tires, lories etc. (Fig. 6) in Bundibugyo Village located at the foothills of the Ruwenzori Mountains (Fig. 7). We collected also many larvae of Ae. simpsoni from colocasia axils in Bundibugyo Village. Haddow, Gillett and Mukwaya claim that this population is anthropophilic. Ae. africanus, Ae. argenteopunctatus and Toxorhynchites brevipalpis larvae were abundant in paw-paw treeholes in Sempaya Village.

On our return trip from Bwamba we stopped for overnight at Queen Elizabeth National Park on 26 August and continued in our trip to Mbarara the next day.

c. Mbarara, Ankole District. A survey for larvae of Ae. aegypti was done in Biharve Village in distance 15 km NE of Mbarara. We have found Ae. aegypti larvae in discarded tires located under roof of a house (Fig. 8). A sample of live larvae was taken for colonization and further investigation. This locality is in elevation of 1,500 m.

Further survey for breeding of Ae. aegypti was done on several places between Biharve and Lyatonde, which is the last village of the Ankole District.

d. Lyatonde. An extensive survey for outdoor and indoor breeding of ae. aegypti in Lyatonde village yielded many larvae from metal drums, clay water-pots and tires located at human dwellings outdoors. No larvae were collected from indoors. Banana plantations and corn fields are common in the village. They have patchy distribution, mostly in depressions between hills. The vegatation of the hills represents scattered trees and bushes (Fig. 9). Several samples of live Ae. aegypti larvae were collected for laboratory rearing.

e. Masaka, Masaka District. Masaka was the last locality where we made survey for indoor and outdoor breeding of Ae. aegypti in Uganda. We checked several houses in a suburban area of Masaka city. We found larvae in a metal drum placed under roofs to collect rain water for domestic use. A sample of live larvae was collected for colonization.

3. Laboratory Findings

Larvae of Ae. aegypti from five different localities, Kampala, Bundibugyo, Mbarara, Lyatonde and Masaka were successfully shipped to the Mosquito Biology Unit at Mombasa and reared to adult stage. Females were fed on man and mice to get eggs. Eggs were shipped to the Vector Biology Laboratory, UND. Rearing into next generation was also successful. The females from Bundibugyo (Bwamba) did not lay egg by the time when eggs of other four populations were shipped

to the United States. All mosquitoes from four above mentioned populations fit Mattingly's (1957) description of Aedes aegypti formosus, having deep black color of cuticle and scales.

Autogeny.

All four populations were tested for autogeny. No blood was offered to females for the first ten days, after emergence. Various degrees of autogeny was found in all of them. No autogenous development was reported in field populations of Ae. aegypti before. Lea (1964) was able to get eggs from a laboratory strain of Ae. aegypti which females were fed on egg albumin and 10% sucrose for 8 generations.

The writer found some degree of autogeny in Tanzanian field populations of Ae. aegypti and Ae. subargenteus (unpublished data). The "Autogeny Index" (AIx) for Tanzanian populations was AIx=0.17. The Uganda Ae. aegypti had more than ten times higher autogeny index, AIx= 2.50 than those from Tanzania.

Since nothing is known on autogeny in field populations of Ae. aegypti it is premature to make any conclusions on feeding, autogeny, relation to hosts (if any) and vectorial capacity in Bwamba and other Uganda populations of Ae. aegypti. Perhaps autogeny is responsible for the fact that Ae. aegypti is non-anthropophilic and does not function as a vector of yellow fever in Uganda.

Ten females of the Mbarara population were dissected after ten day feeding on carbohydrate diet. All of them had fully developed eggs (IV - V stage Christophers, 1911) in their ovaries. The number of fully developed eggs per female was between 1-19 average 10.0. The problem of autogeny is being subjected to further investigation at the Vector Biology Laboratory, UND.

C. Field and Laboratory Work in Kenya

I left Entebbe for Nairobi on 28 August and spent one day at the International Center of Insect Physiology and Ecology discussing various scientific problems with the Director of ICIPE, Prof. Thomas Odhiambo and with Drs. R.H. Leuthold, D. Denlinger and T. Dadhialla. I met and had talks also with Mr. Ojal, the Administrative chief of ICIPE. I left Nairobi for Mombasa on 29 August and spent 12 days in field and the MBU laboratory, discussing various aspects of population dynamics, dispersion, movements, host choice and other ecological aspects of inland and coastal populations of Ae. aegypti in Kenya with Drs. W. Hausermann, P. McDonald and D.M. Fanara. I was very well impressed with effort and amount of data collected by all of these three scientists during a period of one year, which is for this type of work a short period of time. Since they reported their results in the 1972 Annual Report and further data are reported in the present report I will not repeat them here.

1. Field test for exophilic-endophilic behaviour of Ae. aegypti in Rabai area

Six plastic traps for testing exophilic-endophilic behaviour of mosquitoes were constructed at VBL. The traps were 150 x 150 x 600 mm in size. Three circular openings were made on each side of the trap for conically shaped entrances of traps made of metal screen and a plastic rim. Six traps were shipped from Notre Dame to Mombasa by air-freight; however, by the seventh day of my staying at MBU the traps did not arrive. Dr. W. Hausermann offered to buy a sheet of clear plastic and make another set of traps. We made a new set of traps in three days, so we could test them at least once before my departure.

Problem

Most of the feral populations of Ae. aegypti do not feed on men inside houses. Being exophilic in their biting behaviour, they feed on their hosts in open. The writer tested several feral and domestic populations for exophilism and endophilism in an olfactometer in the laboratory. Five different hosts (man, rat, chicken, turtle and frog) as representative of mammals, birds, reptiles and amphibians were tested. There was significantly lower response of all feral populations to the all tested hosts. We feel that there must be a behavioural barrier which prevents Ae. aegypti formosus from entering human dwellings.

In our field experiment at Rabai, it was supposed that Ae. aegypti in the Bejuma stream forest are exophilic so they will not enter the baited traps. If they enter the trap they may be endophilic. In our field experiment we used only three kinds of hosts, mice, chicken and frogs. The traps were hung on tree branches in the Bejuma Forest and left overnight. No mosquitoes were found in traps next morning. It is premature to draw conclusions from this experiment because it should be done in many replicates and on various places in forests, peridomestic and domestic habitats using various kinds of bait.

2. Trip to Wasini Island

On 7 September 1972 I made a trip together with Drs. Hausermann, Fanara, McDonald, Mrs. Hausermann, Mrs. Fanara and a laboratory technician, Mr. George Tsuna to a coastal area south of Mombasa and to Wasini Island.

Purpose of the trip

1) To find out whether or not there is breeding of Ae. simpsoni in the coastal area of Kenya and what is the extent of its breeding.

2) To find out whether or not there is breeding of Ae. aegypti in an inhabited offshore coral island.

3) To find out the degree of domesticity in case there is Ae. aegypti present on Wasini Island.

4) What other mosquito species are present on Wasini Island and in villages of the Kenya seashore.

a. Kiwambale village is located about ten miles from the Ocean. Thatched roof houses are scattered through vegetation of the coastal plane. Mango and paw-paw trees are the most abundant there. The ground between clusters of houses is covered with grass and small bush. Pineapples are quite common and are grown in the form of patches in grass among bush. Several hundred of pineapple axils were checked for breeding of Ae. simpsoni. Most of those with water were positive for Ae. simpsoni larvae. About 50 treeholes and coconut steps with water were sampled for mosquito larvae. Some of the flooded holes were positive for Ae. aegypti; other species were Aedes calceatus, A. simpsoni, A. soleatus. Larvae of Ae. aegypti, A. calcatus and Culex fatigans were found in a big metal drum located under a palm tree. A branch of palm tree was tightened to the trunk of the palm and the base of the branch was inserted into the drum. This is a method used by local tribes to collect rain water for domestic use including cooking and drinking. These water drums also become suitable breeding sites for Ae. aegypti larvae.

b. Pemba Channel Fishing Club - Five discarded motor tires located near bush in the Pemba Channel Fishing Club garden yielded about 50 Toxorhynchites brevipalpis larvae (Fig. 10). In some tires Ae. aegypti and Eretmapodites larvae were found.

c. Shimoni Village - This is a small fishing village with few old arabic type houses at the Indian Ocean. Aedes aegypti and Eretmapodites quinquerittatus were found both in treeholes and in junked motor parts.

d. Wasini Island is located one mile offshore, south of Shimoni Village. It is irregular in shape and inhabited on three places (Northeast, Northwest and Southwest). Baobab trees (Adansonia diggitata) and variety of succulent plants are common (Fig. 11). This coral island is built in the shape of an atoll. The central portion is flooded at high tides (Fig. 13). There are several more but smaller and uninhabited coral islands south of Wasini, which were not searched at this time. These islands might be useful for genetic control experiments.

On the atoll rims of the Wasini Island we found breeding of Aedes (St.) vittatus in coral rock-holes (Fig. 12). This population is partly autogenous. We found larvae of Ae. aegypti in both outdoor and indoor containers. A sample of Ae. aegypti was taken from two old "Dugout" types of boats located on the Wasini seashore. In one of them more than 60% were yellow larvae and in the other boat which was only 3 m in distance from the first one only dark larvae occurred. In the village populations

of Ae. aegypti spot abdomen (s) and pale abdomen (pa) mutants occurred in high frequency. In the central part of the island we found larvae of Ae. aegypti formosus in treeholes. On the Southeast side of the island is a palm-tree plantation about two hectares in size. The undertree vegetation represents short (15-25 cm) grass with scattered (30-40 cm) bush (Fig. 14). Coconut shells unseparated from husks were found in piles on many places. Most of the shells with water were positive for larvae of Ae. aegypti (Fig. 15). Adults are dark ssp. formosus.

We left Wasini Island in the late afternoon. On our way back to Mombasa we found a permanent swamp with patches of Cyprus grandis. This is the plant in which Aedes (St.) woodi breeds in its axils. We were not able to get enough specimens of the plant to find whether or not Ae. woodi breeds in this swamp. Water level of the swamp was very high at this period of year and our experience from Tanzania is that populations of Ae. woodi in permanent swamps are always higher in the dry season. Sampling is also easier during the dry season than the rainy one. It is suggested that this locality should be checked for breeding of Ae. woodi between June-August next year.

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Illustrations

Fig. 1. Headquarters of MBU, located on shores of Indian Ocean just north of Mombasa, Kenya. Building is rented for three years; contains research laboratories, insectaries, library, carpenter shop, radiation source plus living quarters of Dr. Hausermann, MBU Field Director.

2. Mpanga Forest located 40 kw SW of Kampala and 16 kw North of Lake Victoria. Thick forest harboring many mosquito species including Ae. africanus, the vector of yellow fever among forest monkeys.

3. Kampala, Uganda; an automobile scrap-heap where Ae. aegypti and Culex pipiens fatigans breed in scrap iron.

4. Colocasia plantation at Bwayise, the habitat with non-anthropophilic population of Ae. simpsoni breeding in plant axils.

5. Colocasia axils as breeding sites of Ae. simpsoni.

6. A habitat in Bundibugyo village where a non-anthropophilic population of Ae. aegypti breeds in man-made containers.

7. Bundibugyo village with the Ruwenzori Mountains in background.

8. The habitat in Biharve village (15 km NE of Mbarara) where larvae of Ae. aegypti were collected from a discarded motor tire.

9. Lyatonde village, breeding habitat of Ae. aegypti outside houses.

10. Discarded motor tires in the Pemba Channel Fishing Club near Shimony Village, Kenya are suitable breeding sites for Toxorhynchites brevipalpis, Ae. aegypti and Eretmapodites quinquevittatus larvae.

11. Baobab trees and variety of succulent vegetation on coral island of Wasini.

12. Coral rock-holes filled with rain water on the atoll rim of Wasini Island breeding site of Aedes (St.) vittatus.

13. Central part of the atoll-shaped coral island of Wasini.

14. Coconut palm-tree plantation of SE side of the coral atoll of Wasini Island. Shells unseparated from husks scattered in grass are suitable breeding sites of Ae. aegypti larvae.

15. Piles of coconut shells in husks as breeding habitats of Ae. aegypti on Wasini Island.

16. Field station of MBU in Rabai study area near Mombasa.

17. Isolated village, Rabai area, where population dynamics of Aedes aegypti is under study.