MOSQUITO SPECIES COLLECTED FROM A MARSH IN WESTERN KENYA DURING THE LONG RAINS[1]

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ABSTRACT. A total of 475,431 mosquitoes representing 8 genera and 43 species were collected from a marsh in the western Kenya highlands to determine species composition and succession in relation to the epidemiology of Rift Valley fever virus. *Culex pipiens* was the most common species, totalling 92.3% of the collection, followed by *Cx. zombaensis* (2.2%), *Anopheles coustani* (1.1%), *An. squamosus* (0.8%), *Mansonia uniformis* (0.6%), *Coquillettidia microannulatus* (0.5%), *Uranotaenia mashonaensis* (0.5%), *Ma. africana* (0.4%) and *Cq. aurites* (0.4%). *Aedes quasiunivittatus* was the first floodwater species to emerge from newly flooded areas and was the most abundant *Aedes* collected, representing 88% of all *Aedes* specimens. *Culex guiarti* and *Cx. zombaensis* colonized newly flooded areas soon after the areas became flooded.

INTRODUCTION

A serological survey of cattle in Kenya indicated that Rift Valley fever (RVF) virus is predominately located in the central and western highlands of the country (Davies 1975). Studies conducted in the central Kenya highlands suggest that RVF virus is maintained during interepizootic periods in transovarially infected floodwater *Aedes* mosquitoes, particularly *Ae. mcintoshi* Huang [as *Aedes lineatopennis* Ludlow (Linthicum et al. 1985)]. Epizootics of RVF are thought to occur after periods of prolonged and widespread rainfall (Davies et al. 1985), when dambo formations (Ackermann 1936, Mackel 1974, Linthicum et al. 1983) containing aedine eggs are flooded, allowing development of *Aedes* species transovarially infected with RVF virus. After infection of susceptible hosts by such *Aedes* vectors, the virus outbreak can be amplified by secondary RVF mosquito vectors of many different genera (Meegan and Bailey 1988). The dominant floodwater *Aedes* breeding habitat in the western Kenya highlands appears to be dambos similar to those in the central highlands region, as well as swamp and marshland margins and drainage areas that become flooded during the rainy seasons.

In the Uasin Gishu and Trans Nzoia districts of the western highlands, the primary vegetation features include forests and derived grasslands and bushlands (ecological zone II, Pratt et al. 1966). The land is interspersed with numerous permanent and temporary swamp and marshland areas to a greater extent than areas in central Kenya, where earlier observations on RVF vectors were made (Linthicum et al. 1983, 1984, 1985). This study was to determine the mosquito species present in a permanent marshland area of the western Kenya highlands after the onset of the long rainy season.

MATERIALS AND METHODS

The study site was located at the Maji Mzuri marsh, a permanent marsh located 9 km E of Moi's Bridge, Uasin Gishu District, Rift Valley Province, Kenya (0°48′N; 35°12′E: altitude 1,981 m). The oval marsh was approximately 250 ha and was similar to South African pans (Gargan et al. 1988). The dominant emergent vegetation in the central part of the marsh was *Typha latifolia* Linn. and *Cyperus latifolius* Poir. Predominant among the grasses along the marsh margins and drainage area were species of *Panicum* and *Echinochiloa*. The mean daily high and low temperatures were 25.4°C and 11.2°C, respectively, with a yearly mean rainfall for the area of 1,183 mm, measured 25 km NW of the study area at the Kitale meteorological station (Kenya Meteorological Department 1984). Precipitation during the study period was measured at Maji Mzuri Estate headquarters, 2 km N of the marsh.

Mosquito pupae were sampled daily throughout the study, from March 31 to May 18, 1989, by sieving 100 dips (0.47-liter dipper) collected along each of 3 discontinuous 100-m sampling lines along the southern 1 km margin of marsh and 3 sampling lines of the same length in the marsh drainage channel exiting from the northern rim of the marsh. Pupae were placed in 0.027-m^3 cages at the marsh edge and adult specimens collected after emergence in the cages.

Collections of resting adults were made daily by walking 10 min along each of the 6 sampling lines employed in the pupal collections using a

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Table 1. Numbers of mosquitoes collected from a marsh in Kenya by 3 methods.

Species	Number of mosquitoes collected: Reared from pupae	Resting adults	Light-CO_2 traps	Total	Total number as % of total collection
Cx. pipiens	12	8,347	430,445[1]	438,804	92.3
Cx. zombaensis	250	163	9,862	10,275	2.2
Cx. antennatus	23	76	1,012	1,111	0.2
Cx. univittatus	4	24	798	826	0.2
Cx. ventrilloni			725	725	0.2
Cx. guiarti	540		6	546	0.1
Cx. bitaeniorhynchus			359	359	<0.1
Cx. vansomerini		93	220	313	<0.1
Cx. mirificus		7	130	137	<0.1
Cx. aurantapex		65		65	<0.1
Cx. theileri			4	4	<0.1
Cx. poicilipes		58	5	63	<0.1
Cx. jinjaensis		3		3	<0.1
Cx. annulioris			15	15	<0.1
Cx. sitiens		4	8	12	<0.1
Cx. tigripes			1	1	<0.1
Cx. toroensis		9		9	<0.1
Cx. hopkinsi		1		1	<0.1
Ma. uniformis			2,917[2]	2,917	0.6
Ma. africana			1,669	1,669	0.4
An. coustani	2	36	5,068	5,106	1.1
An. squamosus		53	3,905	3,958	0.8
An. gambiae			15	15	<0.1
An. dthali			1	1	<0.1
An. smithii			1	1	<0.1
Cq. microannulatus			2,246	2,246	0.5
Cq. aurites		496	1,413	1,909	0.4
Cq. annetti		13	123	136	<0.1
Cq. versicolor			69	69	<0.1
Cq. pseudoconopas			45	45	<0.1
Cq. aurea			2	2	<0.1
Ur. mashonaensis	20	2,217	71	2,308	0.5
Ur. bilineata		222	95	317	<0.1
Ur. balfouri			5	5	<0.1
Ae. quasiunivittatus	521	23	357	901	0.2
Ae. dentatus	95	2	238	335	<0.1
Ae. mcintoshi	2	3	73	78	<0.1
Ae. circumluteolus			4	4	<0.1
Ae. unidentatus		1	2	3	<0.1
Ae. calignosus			2	2	<0.1
Ae. subdentatus			1	1	<0.1
Ml. farquharsoni		128		128	<0.1
Mi. plumosa			6	6	<0.1

[1] Population peaked at end of March and mid-April.
[2] Population peaked in mid-April.

battery powered aspirator (Davis and Gould 1973). Solid-state, army miniature light traps (John W. Hock Co., Gainesville, FL) baited with 1 kg of dry ice pellets as a source of CO_2 (10–15 traps/sampling night), were set biweekly, from March 24 to May 16, 1989, to collect mosquitoes from areas along 1 km of marsh margin and 1 km of marsh drainage area. Mosquito specimens were identified according to reference keys of Edwards (1941), Gillies and de Meillon (1968) and Harbach (1988), and voucher specimens retained.

RESULTS

A total of 475,431 mosquitoes belonging to 8 genera and 43 species were collected as shown in Table 1. Of the 43 species collected, 38 species were present in light trap collections, the remaining 5 species: *Malaya farquharsoni* (Edwards), *Culex aurantapex* Edwards, *Cx. jinjaensis* Edwards, *Cx. toroensis* Edwards and Gibbins and *Cx. hopkinsi* Edwards were collected with the aspirator only. Light trap collections made along the marsh margin were similar to those made along the drainage area with the exceptions that *Anopheles dthali* Patton ($n = 1$), *An. smithii* Theobald ($n = 1$), *Ae. calignosus* (Graham) ($n = 2$), *Ae. subdentatus* Edwards ($n = 1$) and *Cx. poicilipes* (Theobald) ($n = 5$) were found only in collections made along the marsh margin. Also *Ae. unidentatus* McIntosh ($n = 2$) and *Uranotaenia balfouri* Theobald ($n = 5$) were in collections only along the drainage area.

The 3 sampling lines in the drainage area became flooded on different days, as rainfall produced overflow water that moved down the watercourse, inundating each sampling line in succession. The data collected from the first sampling line that was flooded were representative of the 2 other sampling lines in the drainage area, and these data can be used to illustrate species succession in the drainage area from March 31 to May 18, 1989 (Fig. 1). *Aedes quasiunivittatus* (Theobald) was both the first floodwater species to emerge from the newly flooded areas as well as the most abundant, representing 88% (499/566) of the *Aedes* spp. collected as pupae from the drainage area. Other *Aedes* species present were *Ae. dentatus* (Theobald) ($n = 55$) and *Ae. mcintoshi* ($n = 2$). *Culex guiarti* Blanchard ($n = 292$) and *Cx. zombaensis* Theobald ($n = 135$) were collected from the areas soon after flooding, as were *Ur. mashonaensis* Theobald ($n = 6$), *Cx. antennatus* (Becker) ($n = 9$), *Cx. pipiens* Linn. ($n = 5$) and *An. coustani* Lavaran ($n = 2$). Pupal collections made along the marsh margin demonstrated that *Ae. quasiunivattatus* was the first floodwater species to emerge after the water level expanded over previously unflooded banks of the marsh; however, the succession of species was unclear due to an influx and mixing of species already colonizing the marsh water with emerging floodwater species and opportunistic species breeding in the newly flooded margin areas. The pupae collected from the marsh margins, beginning from first day pupae were seen after the margin was flooded on April 13 until May 16, 1989, consisted of: *Cx. guiarti* ($n = 249$), *Cx. zombaensis* ($n = 108$), *Ae. dentatus* ($n = 40$), *Ae. quasiunivittatus* ($n = 23$), *Cx. antennatus* ($n = 14$), *Ur. mashonaensis* ($n = 14$), *Cx. pipiens* ($n = 7$) and *Cx. univittatus* Theobald ($n = 4$).

DISCUSSION

Although many species were found to be well established around the permanent marsh habitat, *Cx. pipiens* was the predominant species. Different collection methods may have revealed additional mosquito species. Light trap collections yielded 38 species, aspirator collections of resting adults yielded 23 species (including 5 species that were not present in light trap collections), and pupal dip collections yielded 10

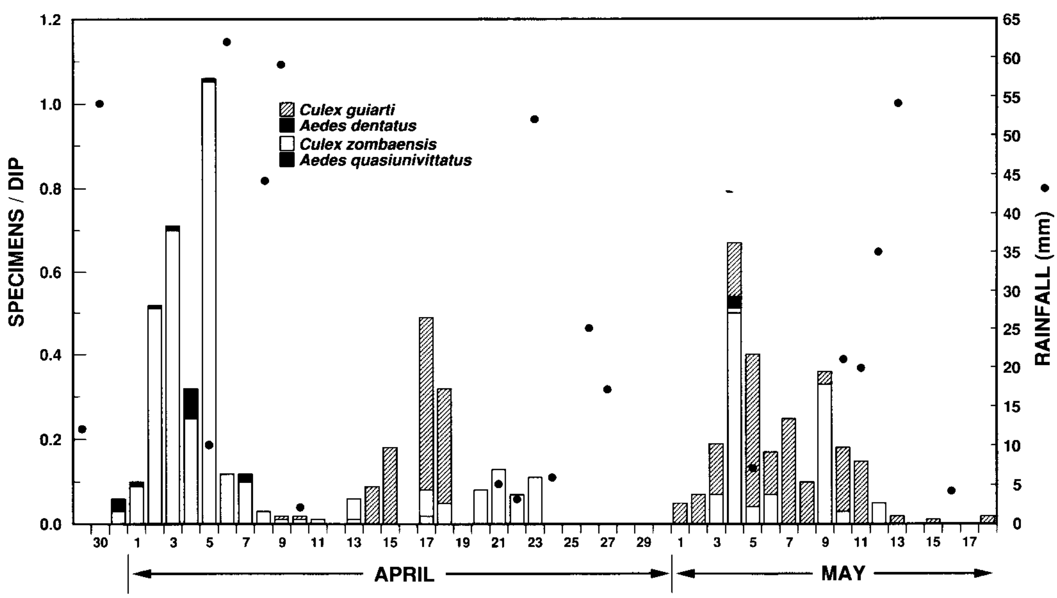

Fig. 1. Mean numbers of *Aedes quasiunivittatus*, *Ae. dentatus*, *Culex guiarti* and *Cx. zombaensis* pupae collected per dip after the Maji Mzuri marsh drainage area became flooded, March 31 to May 18, 1989.

species. Emphasis was placed on those species found near or along the margins of the marsh. In temporarily flooded grassland and forest dambos, only 8 and 6 different species, respectively, were found in collections of immatures (Linthicum et al. 1983, 1984). In the grassland dambo, *Cx. pipiens* was the most commonly found species (Linthicum et al. 1984).

Aedes quasiunivittatus was the first floodwater *Aedes* to emerge from newly flooded areas along both the margins and drainage area of the marsh, and it was also the most abundant *Aedes* collected. Further studies to document whether *Ae. quasiunivittatus* is also the dominant floodwater species in temporarily flooded dambo formations in the western Kenya highlands should be conducted. Linthicum et al. (1983, 1984) showed *Ae. mcintoshi* to be the dominant *Aedes* in dambo formations studied in the central Kenya highlands. A small number of *Culex* pupae, collected in newly flooded areas, began emerging 2 days after the first emergence of *Ae. quasiunivittatus*, indicating either that these species (*Cx. guiarti, Cx. zombaensis* and *Cx. antennatus*) quickly colonized newly flooded areas or that they were carried into the sampling areas with the overflowing marsh water.

Figure 1 illustrates that a second emergence of *Aedes* occurred during the first week of May, as some of the areas in the sampling line that had dried became reflooded during the rainfall in the last week in April. The small numbers of *Cx. pipiens* and *Anopheles* spp. in pupal collections suggest that these species, even though predominate in adult collections, are either slower in colonizing newly flooded areas than *Cx. guiarti, Cx. zombaensis* and *Cx. antennatus*, or breed in areas of the marsh other than along the margins.

The number of *Aedes* specimens collected from this marsh habitat over 56 days was only 1,324 mosquitoes, with a mean of 1 *Aedes* specimen collected per dip recorded during the period when *Aedes* pupae were most abundant. Collections made at a temporarily flooded forest edge dambo in central Kenya (Linthicum et al. 1983) contained more than twice as many *Aedes* pupae per dip as compared with collections made during this study, and collections made in a flooded grassland dambo in central Kenya (Linthicum et al. 1984) yielded almost 5 *Aedes* pupae per dip.

The prevalence of RVF antibodies in many cattle (Davies 1975) in the western Kenya highlands may be related to the regular emergence of floodwater *Aedes* vectors. In view of the incrimination of *Ae. mcintoshi* as a maintenance host of RVF in the central Kenya highlands (Linthicum et al. 1985), further studies are needed to document the occurrence and abundance of *Ae. mcintoshi* and other floodwater *Aedes* in the western Kenya highlands, particularly in dambo formations. The paucity of significant numbers of *Aedes* specimens [particularly *Aedes* (*Neomelaniconion*) species] and the tremendous numbers of *Cx. pipiens* and other *Culex* species in the collections indicate that permanent marsh areas in western Kenya could serve as an important source of RVF epizootic vectors, but would be unlikely to play a role in the maintenance of RVF virus. *Culex pipiens* and *Cx. zombaensis* have been reported as epizootic vectors in Egypt and South Africa, respectively (Hoogstraal et al. 1979, McIntosh et al. 1983).

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