base tank mixes of Arosurf MSF and Abate 4-E applied at application rates of 5–6 gal/acre from a roadside ditch truck gave 100% control of mixed larval and pupal populations of *Cx. nigripalpus* Theobald, *Psorophora columbiae* Dyar and Knab and *Aedes taeniorhynchus* Wiedemann in 24 or 48 hr. Abate can also be easily mixed with Arosurf MSF with minimal agitation (e.g., hand shaking) for application of the technical products at recommended rates. The efficacy of these formulations in hand sprayers has also been demonstrated under field conditions. Observations of rapid kill of larvae in areas that were far removed from the points of application indicated the Arosurf-induced surface spreading of Abate 4-E throughout the habitat prior to solubilization.

Further laboratory and field evaluations are planned to determine the operational feasibility, environmental safety and cost-effectiveness of the Arosurf MSF and diesel-base or Abate 4-E formulations.

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OBSERVATIONS OF THE BITING ACTIVITY OF MOSQUITOES AT A FLOODED DAMBO IN KENYA[1]

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The biting habits of mosquitoes associated with flooded dambos (Ackermann 1936) in Kenya may be of importance in understanding their role in the ecology of Rift Valley fever (RVF) virus and other viruses. No studies of the biting habits of mosquitoes in East Africa have specifically dealt with the dambo associated species (Haddow 1960), several of which have been incriminated as vectors of RVF (Linthicum et al. 1983). Rift Valley fever is primarily a cattle and sheep disease with man becoming infected when in close association with these animals (W.H.O. 1982). In areas of Kenya, where the disease occurs, herdsman graze their cattle in and around dambo formations. The purpose of this study was to determine: (1) the mosquito species feeding on man and cattle, and (2) the time(s) of the diel with which mosquito blood feeding activity occurred.

The study was conducted on a ranch at the northeastern margin of the Athi plains, 7 km SE of Ruiru, Thika District, Central Province, Kenya (1°12's; 37°E), at an elevation of 1500 m. The dambo was situated in an area of bushed grasslands along the Kamiti River (ecological zone III, Pratt et al. 1966). It showed zonal differentiation that is typical of a dambo (Mackel 1974, Linthicum et al. 1983) with predominantly sedge (*Cyperus immensus* C.B. Clarke) in the seepage zone with the grass *Digitaria abyssinica* (A. Richard) Stapf in the remainder of the site. On April 26–27, 1983, overflow from the Kamiti River flooded the study site. A generation of mosquitoes emerged from the flooded dambo which contained standing water until May 9, 1983.

A continuous 96 hr human bait collection (1000 hr May 10–1000 hr May 14, 1983) and a continuous 48 hr biting collection at a single calf (1100 hr May 12—1100 hr May 14, 1983) were made. For the human bait collection 2 men (part of a 4 man rotating team) were positioned

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together in the dambo so that they could capture mosquitoes landing on their partner as well as on themselves. Mosquitoes were collected singly in tubes as they began to feed. The time and date of capture of each specimen was noted on the tube. A yearling calf, weighing approximately 100 kg, was tethered to a stake on a 5 m rope about 50 m from the 2 human collectors. The calf was given water and allowed to graze in the dambo. Another man continually collected specimens as they landed and started to probe on the calf. Specimens were placed in a tube and marked by time and date of capture. Flashlights were used for illumination during the periods of darkness. The tubes were returned to the laboratory for identification.

A 2 × 2 contingency table with Yates' continuity correction was used to test whether *Aedes lineatopennis* (Ludlow), compared to the other mosquito species, showed any apparent preference for one of the host species. The test was repeated for *Ae. cumminsii* (Theobald) and *Ae. dentatus* (Theobald). We refer to apparent preference because we are assuming that once a species landed on the bait it was just as likely to be collected as any other species. The number of specimens of *Ae. lineatopennis, Ae. cumminsii* and *Ae. dentatus* captured during each hourly period (30 minutes before and after the hour) were totalled for each sampling date. These sums were then converted to "Williams' mean" (M_w) (Williams 1937). This modification of the geometric mean accommodates zero values and measures central tendency (Haddow 1960). Relative blood feeding rate for the 3 most common species collected was determined by calculating from M_w values, the percent of total blood feeding occurring during any one hr period. The number of *Ae. lineatopennis* specimens collected during each hour period plus one was converted to the natural logarithm to normalize the data so that an analysis of variance (ANOVA) could be performed. A standard *t*-test was used on data with homogeneous variance and a modified *t*-test on data with heterogeneous variances (after Bailey 1983). An ANOVA was not performed on the other species because of insufficient numbers.

Air temperature, relative humidity and wind velocity were recorded hourly at the study site. Air temperatures ranged from 33°C (day) to 13°C (night) during the 4 day period in which observations were made. Relative humidity varied from 95% during the night to 30% during the day. There was complete cloud cover during each of the 4 nights, with ceilings ranging from 150 to 1070 m above ground level. During the day, cloud coverings ranged from thin-partial to complete with ceilings of 300-1200 m above ground level. Surface winds did not at any time exceed 10 kph. Local sunrise and sunset were at 0628 and 1830 hr Eastern African Standard Time, respectively. The climatic conditions encountered were well within the normal limits reported by the Kenya Meteorological Department for this area in the month of May.

A total of 2,324 female mosquitoes were captured and identified (Table 1). Nine species, represented by 1,446 specimens, were collected on human bait over the 96 hr period. Seven species, represented by 878 specimens, were collected on calf bait over the 48 hr period. *Aedes lineatopennis* was by far the most common species at both human and calf baits. This observation is of particular significance as an isolation of RVF virus has been made from a pool of 12 *Ae. lineatopennis* females collected near our study site during an epizootic in cattle (Davies and Highton 1980). *Aedes lineatopennis* showed an apparent preference for the calf when compared to all other species ($\chi^2 = 53.00$; df = 1; $p<0.01$). Herds of 300–400 cattle grazed through the dambo area each day during this study period, and they were accompanied by one or two herdsmen. These cattle were held in pens throughout the night about 1 km from the nearest dambo; the herdsmen returned to their homes 2–3 km away. The large numbers of bovine hosts available to the dambo populations of *Ae. lineatopennis* during the day possibly explains why blood meal analysis has shown that these mosquitoes feed almost exclusively on cattle (Linthicum et al., unpublished data). A previous study also reported that the majority of *Ae. lineatopennis* captured in Western Kenya had fed on bovines (Chandler et al. 1976). Both

Table 1. Numbers of mosquitoes collected from human and calf bait at a dambo in Thika District, Central Province, Kenya, May 1983.

	Type of Bait			
	Human*		Calf**	
Species collected	No	%	No	%
Ae. lineatopennis	1235	85.4	835	95.1
Ae. cumminsii	60	4.2	3	0.3
Ae. dentatus	116	8.0	28	3.2
Ae. sudanensis	18	1.3	1	0.1
Ae. circumluteolus	5	0.4	5	0.6
Ae. unidentatus	2	0.1	—	—
An. gambiae s.l.	2	0.1	—	—
An. coustani	6	0.4	—	—
Cq. aurea	2	0.1	5	0.6
Cx. pipiens	—	—	1	0.1
Totals	1446		878	

* Collections are from 2 men over a period of 96 hrs (May 10–14, 1983).

** Collections are from one calf over a period of 48 hrs (May 12–14, 1983).

Ae. cumminsii (χ^2 = 30.86; df = 1; $p<0.01$) and *Ae. dentatus* (χ^2 = 23.05; df = 1; $p<0.01$) showed an apparent preference for human bait when compared to all other species.

The biting activity of *Ae. lineatopennis* at human and calf bait, and *Ae. cumminsii* and *Ae. dentatus* at human bait is shown in Fig. 1. At human bait, *Ae. lineatopennis* biting activity is distinctly bimodal with 30% occurring in a 2 hr period just before and immediately after sunset and over 30% occurring in the 4 hr period extending from 1 hr before to 3 hrs after sunrise. Biting activity during these periods was significantly different from that observed during the other periods of the day (t = 9.22; df = 20; $p<0.0001$). Biting activity during the night (2000–0500 hr) was not significantly different from that during the day (1000–1600 hr) (t = 1.38; df = 7; $p>0.05$). Two peaks in numbers collected from calf bait were documented; but these intervals were not significantly different (t = 1.52; df = 22; $p>0.05$) from other periods of the day. There was no significant difference between the biting activity at the calf in the daytime compared to the night (t = 0.91; df = 8; $p>0.05$).

The biting activity of *Ae. cumminsii* at human bait is strongly unimodal, 50% of the specimens were captured in the 2 hr interval immediately before and after sunset (1800–1900 hr). Diurnal biting (0700–1700 hr) represented only 6% of the specimens captured. Only 3 specimens were taken on the calf. There was a single pronounced peak in the biting activity of *Ae. dentatus* at human bait (57% of the total activity), from 1 hr before sunset to 2 hrs after sunset (1800–2000 hr). Biting activity continued at a low level during the day. Activity peaks were ill-defined at calf bait, but almost 70% of the captures were made between 1600 and 2200 hr.

At human bait *Ae. sudanensis* (Theobald) was collected during crepuscular and nocturnal periods. Only one specimen was collected from the calf bait. *Aedes unidentatus* McIntosh, *Anopheles coustani* Laveran and *An. gambiae* Giles *sensu lato* were not collected at the calf. *Aedes circumluteolus* (Theobald) and *Coquillettidia aurea* (Edwards) were collected both at human and

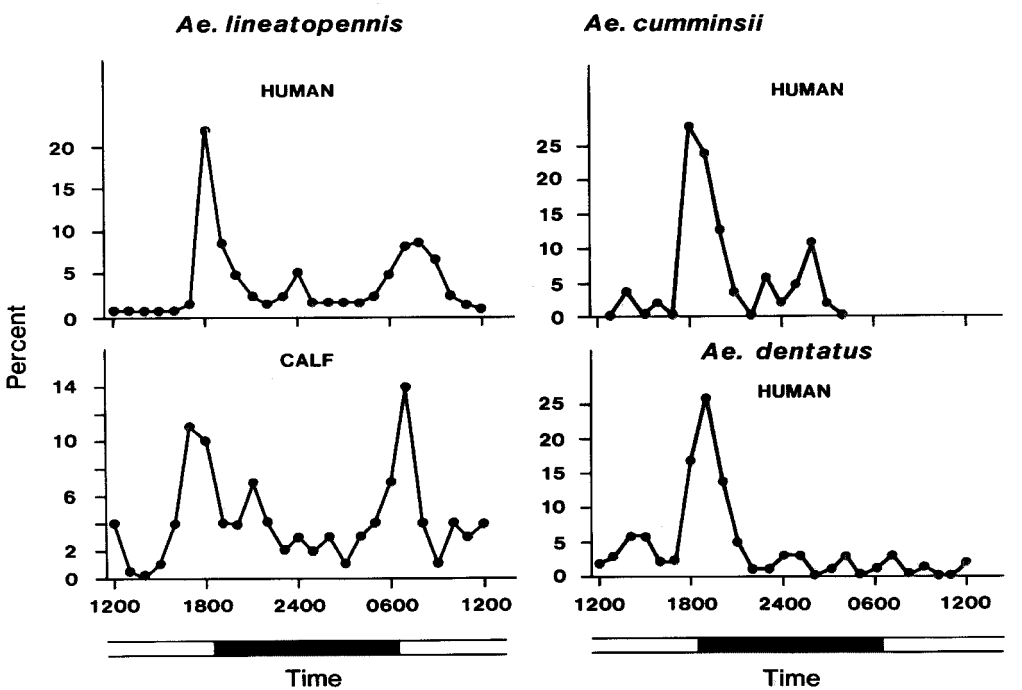

Fig. 1. Numbers of *Aedes lineatopennis* captured from human and calf bait, and *Ae. cumminsii* and *Ae. dentatus* from human bait. Collections were conducted continuously at human and calf bait for 96 and 48 hrs respectively at a dambo in Thika District, Central Province, Kenya, May 1983. Calculated as Williams' mean and expressed as a percent of the total.

calf bait at night. A single *Culex pipiens* Linnaeus was collected at the calf at night.

In conclusion, *Ae. lineatopennis* was the most common species found feeding on both human and calf bait at a dambo 2 weeks after it had flooded. *Aedes lineatopennis* showed an apparent preference for the calf where its biting activity was virtually continuous throughout the day. These observations provide support for the hypothesis that in RVF epizootic areas in Kenya cattle are initially infected with transovarially transmitted virus by *Ae. lineatopennis* shortly after dambos flood.

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EVIDENCE FOR AUTOGENOUS EGG DEVELOPMENT IN *CULEX PIPIENS* IN BRITISH COLUMBIA

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Culex pipiens Linn. was evidently introduced into the lower mainland of British Columbia around the turn of the century (Hearle 1926) and is now an abundant species, replacing the native *Culiseta incidens* (Thomson) in temporary larval habitats and colonizing sewage lagoons and drainage ditches. Its status as a pest of humans in this area is uncertain and, although it is known to bite indoors late in the year (Belton 1983), there is little evidence that it bites people outdoors.

Our investigations in the greater Vancouver area from August to November 1983 indicate that *Cx. pipiens* will take human blood both when it enters houses and in captivity. Several authorities have suggested that specimens biting humans arise from non-hibernating 'domesticated' and primarily autogeneous populations (the so-called *molestus* form) rather than those from more rural environments that take blood from birds (the *pipiens* form). Such populations were discussed in detail at a seminar on *Cx. pipiens* held in Geneva nearly 20 years ago (see, for example, Barr 1967, Spielman 1967).

The following investigation of this topic is part of a wider study of the species in Canada that will be published in more detail elsewhere.

REARING CONDITIONS: Larvae of *Cx. pipiens*

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