HHS Public Access

Author manuscript

J Med Entomol. Author manuscript; available in PMC 2019 May 26.

Published in final edited form as:

J Med Entomol. 2012 November ; 49(6): 1289–1306. doi:10.1603/me12111.

Mosquitoes of Western Uganda

J.-P. Mutebi[1], **M. B. Crabtree**[1], **R. J. Kent Crockett**[1], **A. M. Powers**[1], **J. J. Lutwama**[2], and **B. R. Miller**[1]

[1]Centers for Disease Control and Prevention (CDC), 3150 Rampart Road, Fort Collins, Colorado 80521. [2]Department of Arbovirology, Uganda Virus Research Institute (UVRI), P.O. Box 49, Entebbe, Uganda.

Abstract

The mosquito fauna in many areas of western Uganda has never been studied and is currently unknown. One area, Bwamba County, has been previously studied and documented but the species lists have not been updated for more than 40 years. This paucity of data makes it difficult to determine which arthropod-borne viruses pose a risk to human or animal populations. Using CO_2 baited-light traps, from 2008 through 2010, 67,731 mosquitoes were captured at five locations in western Uganda including Mweya, Sempaya, Maramagambo, Bwindi (BINP), and Kibale (KNP). Overall, 88 mosquito species, 7 subspecies and 7 species groups in 10 genera were collected. The largest number of species was collected at Sempaya (65 species), followed by Maramagambo (45), Mweya (34), BINP (33), and KNP (22). However, species diversity was highest in BINP (Simpson's Diversity Index 1-D = 0.85), followed by KNP (0.80), Maramagambo (0.79), Sempaya (0.67), and Mweya (0.56). Only six species (*Aedes* (*Aedimorphus*) *cumminsii* (Theobald), *Aedes* (*Neomelaniconion*) *circumluteolus* (Theobald), *Culex* (*Culex*) *antennatus* (Becker), *Culex* (*Culex*) *decens* group, *Culex* (*Lutzia*) *tigripes* De Grandpre and De Charmoy, and *Culex* (*Oculeomyia*) *annulioris* Theobald), were collected from all 5 sites suggesting large differences in species composition among sites. Four species (*Aedes* (*Stegomyia*) *metallicus* (Edwards), *Anopheles* (*Cellia*) *rivulorum* Leeson, *Uranotaenia* (*Uranotaenia*) *chorleyi* Edwards, and *Uranotaenia* (*Uranotaenia*) *pallidocephala* Theobald) and one subspecies (*Aedes* (*Stegomyia*) *aegypti formosus* (Walker)) were collected in Bwamba County for the first time. This study represents the first description of the mosquito species composition of Mweya, Maramagambo, BINP and KNP. At least 50 species collected in this study have previously been implicated in the transmission of arboviruses of public health importance suggesting a high potential for maintenance and transmission of a wide variety of arboviruses in western Uganda.

Keywords

Mosquitoes; species composition; Uganda; Mweya; Sempaya; Maramagambo; Bwindi; Kibale; arbovirus vectors

Introduction

A considerable amount of information on species composition and ecology of the mosquitoes of Uganda was compiled between the mid-1930s and the early 1970s. The bulk

of this information was from the entomological investigations component of the arbovirus surveillance program conducted at the Uganda Virus Research Institute (UVRI) in Entebbe. The UVRI, then known as the Yellow Fever Research Institute, was established in 1936 by the International Division of the US Rockefeller Foundation. Its primary mission was to study yellow fever epidemiology in eastern Africa and, specifically, to investigate the extent of the spread of yellow fever virus (YFV) eastward from West Africa. In the course of these investigations mosquito species composition for some locations in Uganda were described (Smithburn et al. 1941, Smithburn and Haddow 1944, Smithburn and Haddow 1946, Smithburn et al. 1946, Haddow 1946, Haddow et al. 1948, Haddow and Mahaffy 1949, Haddow and van Someren 1950, Haddow et al. 1951, Smithburn and Haddow 1951, Dick and Haddow 1952). However, arbovirus surveillance was undertaken in only a few areas and therefore mosquito species compositions for much of Uganda are unknown. Further, mosquito species composition descriptions were not compiled in concise regional mosquito species lists but rather were scattered in numerous publications many of which are older archives or obscure regional journals that are not easily accessible. The only exception is the monograph by Haddow et al. (1951) which described in detail the more than 160 mosquito species records from Bwamba County in western Uganda for the ten year period from 1936 to 1946. Unfortunately, the efforts initiated by the Rockefeller Institute were interrupted by the civil instabilities in Uganda during the 1970s and 1980s. Recently, arbovirus research and surveillance activities have resumed at UVRI, but have mainly been limited to monitoring outbreaks, such as the O'nyong-nyong virus (ONNV) outbreak in 1996 (Lutwama et al. 1999). Currently, most species composition descriptions date between the mid-1930s and the early 1970s, and no records have been updated for over 40 years.

In 2008, the US Centers for Disease Control and Prevention (CDC) and UVRI re-established the arbovirus surveillance program with the primary aim of screening for and describing arboviruses of public health and veterinary importance currently circulating within Uganda. In this manuscript, we describe and discuss mosquito species composition at five locations in western Uganda including: Sempaya, in Semliki National Park (SNP), Mweya, in Queen Elizabeth National Park (QENP), Maramagambo Forest, in QENP, Bwindi Impenetrable National Park (BINP) and Kibale National Park (KNP) and discuss their possible role as arbovirus vectors.

Materials and Methods

Study sites

A map showing the location of the five study sites is provided in Figure 1 and Figure 2 includes photographs depicting the typical vegetation/landscape at each site.

Sempaya village (0^{O} 49' N: 30^{O} 10'E) is located in SNP, which is in extreme western Uganda in Bwamba County (Bundibugyo District), west of the Ruwenzori mountain range (Fig. 1). It is located between the Buranga hot springs and the foothills of the Ruwenzori mountain range approximately 15 km northwest of Fort Portal. The ecosystem of SNP is primarily that of dense, moist, semi-deciduous, tropical lowland forest (Fig. 2A) and is part of the great Ituri Forest that stretches into the Democratic Republic of Congo. Rainfall occurs year round with peaks from March to May, and September to December; average

rainfall at the study site is 2,558 mm per annum (Monaghan et al. 2012, Haddow 1945). The mean annual temperature is 24.7^{O}C with a range of 19.6–29.4^{O}C (Monaghan et al. 2012). The altitude at the trap site was between 678 m and 753 m above sea level.

Mweya, located roughly in the middle of QENP (0^{O} 11’ S: 29^{O} 54’ E) is at the junction between Lake Edward and the Kazinga Channel (Fig. 1). The trap locations were close to Mweya Safari Lodge at an altitude of 917–956 m above sea level. The ecosystem of Mweya is mostly open savannah and grassland vegetation (Fig. 2B). Mweya is characterized by two wet seasons, March to May and October to December, and the average annual precipitation at the study site is 809 mm (Monaghan et al. 2012). The average daily temperature is 24.7°C (range 20.2–30.3°C) (Monaghan et al. 2012).

Maramagambo (0° 16’ S: 30° 03’ E), is a large, moist, semi-deciduous forest (Fig. 2C) in the southeastern extremity of QENP, west of the Kyambura escarpment (Fig. 1). It is located approximately 20 km east of Mweya at an altitude of approximately 969 m above sea level (Monaghan et al. 2012). Similar to Mweya, there are two wet seasons, March to May and October to December. The average annual precipitation and average daily temperature are the same as Mweya.

Kibale National Park (0° 34’ N: 30° 22’ E) is located in Kabarole District, approximately 35 km east of Fort Portal (Fig. 1). The park encompasses approximately 766 km^2 and the predominant ecosystem is moist, medium altitude, evergreen and semi-deciduous forest (Fig. 2D). Mosquito trapping sites were on the perimeter of the Makerere University Biological Field Station. The altitude range at the study site is 1,390–1,625 m above sea level. The average annual temperature is 19.3°C (range 16.2–23.6°C), and the average annual rainfall is 1,671 mm (mailto:http://weber.ucsd.edu/~jmoore/apesites/Kibale/Kibale.html).

Bwindi Impenetrable National Park (01°03′S 29°43′E) is located in southwestern Uganda on the eastern edge of the Albertine Rift Valley (Fig. 1). It encompasses 331 km^2 consisting of both medium altitude, moist, evergreen forest and high altitude, submontane forest (Langdale-Brown et al. 1964) (Fig. 2E). Bwindi is one of the most diverse forest ecosystems in East Africa, with at least 223 known trees species which is approximately 53% of Uganda’s tree flora (Kakuru 1993). Mosquito collections for this study were conducted close to the park headquarters near the Buhoma gate. At this location, the annual mean temperature range was 16.9–20.7°C (Monaghan et al. 2012). Annual rainfall at the study site ranges from 1,590 mm to 1,807 mm (Monaghan et al. 2012) occurring year round with two peaks, from March to April and from September to November (Eilu and Obua 2005). The elevation at the study site is 1,470–2,165 m above sea level (Monaghan et al. 2012).

Mosquito Collections

Mosquitoes were captured by using CDC miniature light traps (Clarke Mosquito Control, Roselle, IL) with dry ice, a source of carbon dioxide, as an attractant. At Sempaya, 3 collection trips were conducted from November 8–12, 2008, June 7–12, 2009, and January 15–18, 2010. Twelve to 24 traps were used and approximately half of them were placed in the forest, ≥50 m apart to minimize interference. The remaining traps were placed along

forest edges, approximately 100 m apart in locations sheltered from direct sunlight and wind.

Three collection trips were conducted at Mweya, November 14–17, 2008, June 14–20 2009, and January 19–21, 2010. Traps were placed in two general areas: 1) adjacent to the student hostels on the eastern side of Mweya Safari Lodge and 2) adjacent to the jetty and along the Kazinga Channel north of the lodge. Twelve to 24 traps were split equally between the jetty and hostel areas. The collection site near the hostel was mostly flat savannah grassland with scattered shrubs; traps were placed within the shrubs to protect them from direct sunlight and wind. The collection area adjacent to the jetty was in a lightly-wooded, small valley sheltered from the wind where the nearby banks of the Kazinga Channel were covered with papyrus and other fresh water hydrophytes. Traps here were hung in the trees.

Two collection trips were conducted in Maramagambo Forest June 16–18, 2009 and January 19–22, 2010. We used 6–24 traps, all of which were placed along the trail to the python cave within the forest. Maramagambo is not a typically dense tropical forest exhibiting little undergrowth due to clearing of fire materials by local inhabitants; therefore, the traps were placed approximately 100 m apart to minimize interference.

Two collection trips were conducted in BINP: January 23–26, 2010 and June 14–17, 2010. On each trip, 24 traps were used. On the first trip 20 traps were placed along trails and paths in the forest and four traps were placed near the Buhoma Gate administration buildings and in the Buhoma Lodge yard, in a clearing at the northern edge of the park. On the second trip half of the traps were placed outside the forest in the Bwindi Community Hospital yard, the Buhoma Primary School yard, in several banana and tea plantations, and in communal grazing fields adjacent to BINP. The rest of the traps were placed along trails in the forest.

A single collection trip was made to KNP from June 19–22, 2010. Twenty four traps were used at this location, all of which were placed on the boundaries of a clearing around the Makerere University Biological Field Station (MUBFS) on the western edge of the park. The traps were hung approximately 50 m apart on tree branches.

Mosquito processing

Mosquitoes were collected from traps each morning, chilled on dry ice, separated from other arthropods and counted into cryotubes. The tubed mosquito samples were kept frozen either on dry ice or in liquid nitrogen dry shippers until shipped to the CDC laboratory in Fort Collins, CO, for identification and processing. At the CDC, the mosquitoes were identified to species on the basis of morphological characters by using the keys of Edwards (1941), Jupp (1985), Gilles and De Mellion (1968), Gilles and Coetzee (1987) and Huang (2004), supplemented with notes by Haddow et al. (1951), Gillett (1946), Corbet (1958) and Gillett (1972). Voucher specimens for each species were kept for future reference and for identification consultations.

Diversity Indices

Species richness and species diversity were calculated for each location and collection period. Species richness is reported as the number of mosquito species at each location.

Species diversity was estimated by calculating the Simpson Index (Simpson 1949). The Simpson Index (D), which accounts for both species richness and the relative abundance of each species, was calculated as $D = \Sigma n(n-1) / N(N-1)$ where n = the total number of mosquitoes of a particular species and N = the total number of mosquitoes of all species in each collection. For simplicity, we also report the Simpson's Index of Diversity (1-D), which is interpreted as the greater the index, the greater the sample diversity. An index of 0 would indicate perfect homogeneity whereas an index of 1 would indicate perfect heterogeneity.

Results and Discussion

A total of 67,731 adult mosquitoes were collected from all 5 locations (Table 1), with 39,037 collected at Mweya, 22,498 at Sempaya, 1,567 at Maramagambo, 1,705 at BINP, and 2,924 at KNP. Ten mosquito genera, (*Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Culiseta*, *Eretmapodites*, *Mansonia*, *Mimomyia*, *Orthopodomyia*, and *Uranotaenia*) were represented in the collections, but not all 10 genera were collected from any single location (Fig. 3). The greatest generic richness was found at Sempaya (9 genera), followed by BINP (8), Maramagambo (7), Mweya (6) and lastly KNP (5) (Fig. 3). The absence of certain genera at some sites is intriguing and suggests discontinuity in mosquito generic distribution in western Uganda. For example, the genus *Uranotaenia* was not collected from KNP or Mweya, however, collections were conducted during only one season at KNP therefore limited sampling may have precluded capture of specimens in this genus. In contrast, collections at Mweya comprised multiple seasons in different years suggesting that the genus *Uranotaenia* is either extremely rare or completely absent at this location. An additional example, the genus *Mimomyia* was not collected in KNP or Maramagambo (Fig. 3) and the genera *Eretmapodites* and *Mansonia* were not collected in KNP. The genera *Orthopodomyia* and *Culiseta* were only collected in KNP and Sempaya, respectively, (Table 1) and only in small numbers suggesting either the abundance of these genera is low or that they were not attracted to the CO_2-baited light traps.

In Sempaya, Mweya and BINP, *Culex* species made up the largest proportion of the collections, whereas *Aedes* and *Coquillettidia* species made up the largest proportion of the collections at Maramagambo and KNP, respectively. Overall, the most diverse genera in the collections were *Culex* (27 species) and *Aedes* (26 species) (Fig. 3), and *Culex* species made up by far the largest proportion of the total collection (51,346 mosquitoes) (Table 1). The second and third most frequently collected species were in the genus *Coquillettidia* (5,621 mosquitoes) and *Aedes* (5,086 mosquitoes), respectively (Table 1). It is interesting to note that mosquitoes in the genus *Coquillettidia* were very common in the forest ecosystems of Sempaya, Maramagambo, KNP and BINP but relatively rare in Mweya which is mostly open grassland (Figs. 2 and 3). *Coquillettidia* mosquitoes were sixth in abundance in Mweya with only 173 (0.43%) specimens collected. In contrast *Coquillettidia* mosquitoes were the most abundant in Kibale (67.96%), second most abundant in BINP (40.7%) and Maramagambo (31.66%), and third most abundant in Sempaya (10.1%).

Overall a total of 88 mosquito species, 7 subspecies and 7 species groups were identified in western Uganda (Table 1). The greatest species richness was collected at Sempaya (65 species), followed by Maramagambo (45), Mweya (34), BINP (33), and KNP (22) (Table 1).

Of the 100 species, subspecies and species groups collected, only 6 were collected from all 5 sites: *Aedes* (*Aedimorphus*) *cumminsii* (Theobald), *Aedes* (*Neomelaniconion*) *circumluteolus* (Theobald), *Culex* (*Culex*) *antennatus* (Becker), *Culex* (*Culex*) *decens* group, *Culex* (*Lutzia*) *tigripes* De Grandpre and De Charmoy and *Culex* (*Oculeomyia*) *annulioris* Theobald (Table 1). The wide range of variation in species composition among the sites is of interest considering that four of the five sites (Sempaya, KNP, Maramagambo and BINP) are similar tropical forest ecosystems and that all of the study sites were within a relatively short distance (< 240 km) of each other (Fig. 1). This suggests that microecosystems play a significant role in determining species composition.

Diversity indices for each collection are reported in Tables 2 – 6. On average, species diversity was highest in BINP (Simpson's Diversity Index 1-D = 0.85), followed by KNP (0.80), Maramagambo (0.79), Sempaya (0.67), and Mweya (0.56). While Sempaya had the highest species richness, it was not consistently the most biologically diverse. This finding is likely due to *Culex* (*Culex*) *perfuscus* Edwards comprising a large proportion of the collections from this site in November 2008 and June 2009 (Table 2). Species diversity fluctuated widely at Sempaya among the three sampling periods, ranging from 0.37 – 0.91. While the overall numbers of mosquitoes collected at Maramagambo and BINP (Tables 4 and 5) was relatively low, these two locations had the highest species richness and their biological diversity index was consistently high during both seasons sampled at each of these locations.

Mosquito collections at Sempaya

At Sempaya, 22,498 mosquitoes were collected: 4,343 in November 2008, 16,607 in June 2009 and 1,528 in January 2010 (Table 2). A total of 65 mosquito species in 9 genera (*Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Culiseta*, *Eretmapodites*, *Mansonia*, *Mimomyia* and *Uranotaenia*) were collected at this site (Table 2). The largest number of species were in the genera *Aedes* and *Culex* (19 species each), followed by *Coquillettidia* (8), *Uranotaenia* (8), *Anopheles* (4), *Mimomyia* (3), *Mansonia* (2) and 1 each in the genera *Culiseta* and *Eretmapodites* (Fig. 3). The number of species collected was 27 in November 2008, 59 in June 2009 and 38 in January 2010 (Table 2) suggesting seasonal variation in species abundance and composition. The species captured most frequently at Sempaya was *Cx. perfuscus*, which made up 50.7% of the mosquitoes collected (Table 2). This differs from previously published collection records for this area which reported that the most frequently captured species were *Aedes* (*Stegomyia*) *africanus* (Theobald), *Mansonia* (*Mansonioides*) *africana* (Theobald) and *Anopheles* (*Celia*) *gambiae* (Giles) (Haddow 1945, Haddow et al. 1947, Haddow et al. 1951, Haddow and Mahaffy 1949). However, these previous studies used human-baited collection methods which would not have attracted the non-anthropophilic *Cx. perfuscus* (Haddow et al. 1951). The proportion of *Cx. perfuscus* varied dramatically between the three Sempaya collection trips. In November 2008, this species made up 78.6% of the Sempaya collection, while in June 2009 and January 2010 47.2% and 9.1% were *Cx. perfuscus*, respectively. These differences may be attributed to availability of suitable *Cx. perfuscus* breeding sites which are primarily ground pools that are reduced during dry seasons, especially the extended dry season in January. In support of this hypothesis, the lowest numbers of *Cx. perfuscus* were collected in January 2010 (Table 2).

In addition to *Cx. perfuscus*, the other common species at Sempaya, were *Aedes* (*Neomelaniconion*) *albothorax* (Theobald) (7.1%), *Coquillettidia* (*Coquillettidia*) *pseudoconopas* (Theobald) (6.7%), *Aedes* (*Aedimorphus*) *albocephalus* (Theobald) (4.5%) and *Ae. cumminsii*. (2.6%) (Table 2).

Four species, *Aedes* (*Stegomyia*) *metallicus* (Edwards), *Anopheles* (*Cellia*) *rivulorum* Leeson, *Uranotaenia* (*Uranotaenia*) *chorleyi* Edwards, and *Uranotaenia* (*Uranotaenia*) *pallidocephala* Theobald and one subspecies, *Aedes* (*Stegomyia*) *aegypti formosus* (Walker), were collected in Bundibugyo District (Sempaya site) for the first time. Although *Ae. aegypti formosus* was first described by Walker in 1848, it was not until 1957 that a formal description for this subspecies was published by Mattingly (1957) and a more detailed description has subsequently been published by Huang (2004). Therefore, it is possible that the *Aedes* (*Stegomyia*) *aegypti* Linnaeus listed in Bundibugyo District (Bwamba County) (Haddow 1945, Haddow et al. 1947, Haddow et al. 1951, Haddow and Mahaffy 1949) included *Ae. aegypti formosus* since these subspecies are morphologically very similar and no formal description was available at the time of the collections.

Nearly all of the mosquito species collected in Sempaya had previously been listed in Bundibugyo District by Haddow et al. (1951), suggesting little change in the mosquito fauna of the area in the past 60 years. As mentioned above, the method widely used to collect mosquitoes in Uganda from the mid-1930's to the early 1970's was human-baited catches and therefore, in contrast to our collections, the most abundant mosquito species reported in Bundibugyo District at that time were the highly anthropophilic *Ae. africanus*, *An. gambiae* and *Mn. africana* (Haddow 1945, Haddow et al. 1947, Haddow et al. 1951, Haddow and Mahaffy 1949). *Aedes africanus* is very reluctant to enter enclosed spaces such as mosquito traps and none were captured in our study. Similarly, our CO_2-baited light traps captured only modest numbers of *An. gambiae* and *Ms. africana* compared to the previous studies in this region.

Mosquito collections at Mweya

To our knowledge, the mosquitoes of Mweya, or QENP in general, have not been previously described. A total of 39,037 mosquitoes were collected at Mweya (8,678 in November 2008, 20,888 in June 2009 and 9,471 in January 2010) belonging to 34 species, 2 subspecies and 3 species groups in six genera (*Aedes* (10 species), *Anopheles* (3), *Coquillettidia* (3) *Culex* (14), *Mansonia* (2) and *Mimomyia* (2)) (Table 1 and Fig. 3). The most abundant species collected was *Culex* (*Oculeomyia*) *poicilipes* Theobald accounting for 50.5% of the Mweya collection, followed by *Culex* (*Culex*) *neavei* Theobald (37.8%), *Mansonia* (*Mansonioides*) *uniformis* (Theobald) (5.5%) and *M. africana* (2.1%) (Table 3). Each of the remaining 30 species made up less than 1% of the total collection (Table 3). *Culex poicilipes* and *Cx. neavei*, were the predominant species captured at Mweya; they were 88.3% of the total collections at this location (Tables 1 and 3). The relative abundance of *Cx. neavei* varied from 19.1% in November 2008, to 48.1% in June 2009 to 32.2% in January 2010 (Table 3). June and January are dry seasons; therefore, *Cx. neavei* was more abundant in the dry seasons compared to the wet season. On the other hand, the proportion of *Cx. poicilipes* was

highest during the wet season in November 2008 (72.8%) and lower in the dry seasons in June 2009 (44.5%) and January 2010 (43.4%) (Table 3).

Mosquito Collections in Maramagambo Forest

Like Mweya, the mosquito fauna of Maramagambo Forest, also located in QENP, have never been described. A total of 1,567 mosquitoes belonging to seven genera and 45 species were collected in Maramagambo Forest, 567 in June 2009 and 1000 in January 2010 (Tables 1 and 4). The most commonly captured species at this site were *Coquillettidia* (*Coquillettidia*) *fuscopennata* (Theobald) (23.7%), *Ae. circumluteolus* (21.3%), *Cx. neavei* (10.5%), *Ae. albocephalus* (7.5%), *Ae. cumminsii* (7.3%) *Coquillettidia* (*Coquillettidia*) *metallica* (Theobald) (4.6%), *Culex* (*Culex*) *pruina* Theobald (3.8%) and *Cx. decens* group (3.3%) (Tables 1 and 4). Some variation in species composition was observed between collections from June 2009, when 35 species were collected, and January 2010, when 30 species were collected. *Coquillettidia fuscopennata* was the most frequently collected species on both trips to Maramagambo Forest (Table 4) indicating a dominant presence of this species across seasons. The Kazinga Channel, located adjacent to Maramagambo Forest is edged with papyrus swamps, the preferred breeding habitat for *Cq. fuscopennata*, which may explain the dominance of this species here. In contrast, the relative abundance of the other frequently captured species *Ae. albocephalus, Ae. cumminsii, Ae. circumluteolus, Cq. metallica, Cx. neavei* and the *Cx. decens* group varied dramatically between the two collection trips (Table 4). *Aedes circumluteolus* was much more abundant in June 2009 (48.85%) compared with January 2010 (5.7%), whereas *Ae. albocephalus, Ae. cumminsii, Cq. metallica, Cx. neavei* and the *Cx. decens* group were more abundant in January 2010 (10.6%, 9.8%, 6.1%, 15.8%, and 4.4%, respectively) compared with June 2009 (1.94%, 3%, 1.94%, 1.23%, and 1.23%, respectively) (Table 4). Although both Mweya and Maramagambo Forest are in QENP (Figs. 1 and 3) the most frequently captured mosquito species at these two sites differed. The number of *Cx. poicilipes* collected in Mweya was 19,710, whereas only 2 were collected in Maramagambo (Table 1). On the other hand, 371 *Cq. fuscopennata* were collected in Maramagambo Forest and none were collected in Mweya (Table 1). Taken together these observations suggest strong habitat segregation by *Cq. fuscopennata* and *Cx. poicilipes* for forest and open grassland ecosystems respectively. Further, of the 63 species collected at Mweya and Maramagambo Forest combined, only 16 (25.4%) (Table 1) were collected at both sites showing substantial species composition differences between these two sites despite the close proximity of these two locations. The fact that Mweya is an open grassland and Maramagambo is a tropical forest may explain the species composition differences observed between these two locations.

Mosquito Collections in Bwindi Impenetrable National Park

To our knowledge, this is the first description of the mosquito fauna of BINP. Collections at this site yielded 1,705 mosquitoes; 685 in January 2010 and 1,018 in June 2010 (Tables 1 and 5). A total of 33 species, 4 subspecies and 1 species group belonging to eight genera (Tables 1 and 5) were identified. The species most frequently captured were *Coquillettidia* (*Coquillettidia*) *fraseri* (Theobald), (28.4%), *Culex* (*Oculeomyia*) *annulioris consimilis* Newstead (15.1%), *Cx. decens* group (14.1%), *Coquillettidia* (*Coquillettidia*) *maculipennis* (Theobald) (5.6%), *Culex*(*Culex*) *trifilatus aenescens* Edwards (4.8%), *Culex* (*Culiciomyia*)

nebulosus Theobald (4.8%), *Culex*(*Culex*) *trifilatus* Edwards (4.4%) and *Coquillettidia* (*Coquillettidia*) *aurites* (Theobald) (3.4%) (Table 5). There was little variation in relative abundance of most species between seasons. However, seasonal variations were observed between January and June collections for *Cx. trifilatus aenescens* (0% and 8.1%, respectively) and for *Cx. trifilatus* (1% and 7.2%, respectively). Despite these few exceptions, the general lack of variation in the seasonal abundance of species suggests little variation in weather and habitat conditions between seasons in BINP.

Mosquito Collections in Kibale Forest

Two thousand nine hundred and twenty-four mosquitoes were collected during the single collection trip at KNP in January 2010 (Tables 1 and 6). A total of 22 species, 4 subspecies and species groups belonging to 5 genera were identified from this location. The most frequently captured species was *Cq. maculipennis* which was 38.3% of the KNP collection followed by *Cq. fuscopennata* (19.3%), *Cx. decens* group (9.8%), *Cx. annulioris consimilis* (4.8%), *Cq. fraseri* (4.2%) and *Ae. tarsalis* (4%) (Table 6). To our knowledge this is the first documented account of the mosquito fauna of KNP. Most striking was that only a single species in the genus *Anopheles*, (*Anopheles* (*Anopheles*) *implexus* (Theobald)), was detected at this location and was only 2.1% of the total collection (Table 6). However, collecting *An. implexus* in KNP was not surprising because it is predominantly a forest species (McCrae et al. 1976) and KNP is a forest ecosystem. Further, unlike most mosquito species, the population size of *An. implexus* is not affected by rainfall patterns (McCrae et al. 1976); therefore, populations are usually detectable throughout the year.

Culex neavei *morphological variations*

Numerous morphological variations were noted for *Cx.* (*Culex*) *neavei*, specifically regarding the post-spiracular scales, hind tibia, and sternites. Identification of this species was challenging due the inconsistency of morphological characters observed among individuals within and between collection sites, and was confounded by the conflicting species descriptions of Edwards (1941) and Jupp (1971, 1972). These morphological variations are summarized in Table 7 and pictured in Fig 4. Of the specimens analyzed in Table 7, there was no consistent combination of characters noted among specimens from different locations. All character traits reported previously for this species were noted in our collections, and were consistent with the variations reported by Haddow et al. (1951).

Potential medical importance

A list of mosquito species collected in western Uganda and the arboviruses of medical importance that have previously been isolated from these species are presented in Table 8. Of the 102 mosquito species, subspecies and species groups collected in this study, at least 50 have been implicated in the transmission of arboviruses of public health importance (Table 8). The major epidemic vector species include *Ae. aegypti,* the principal vector of YFV (Monath 1988, Germain et al. 1980), Chikungunya virus (CHIKV) (Jupp and McIntosh, 1988), Dengue viruses (DENV) (Gubler 1986) and Zika virus (ZIKAV) (Marchette et al. 1969). Members of the *Ae. simpsoni* complex, and specifically *Aedes* (*Stegomyia*) *bromeliae* Huang, are epidemic vectors of YFV (Mahaffy et al. 1942, Huang 1986). *Aedes* (*Stegomyia*) *luteocephalus* (Newstead) is a vector of YFV (Germain et al.

1980), CHIKV (Jupp and McIntosh, 1988), DENV (Diallo et al. 2003) and ZIKAV (Marchette et al. 1969). *Anopheles* (Cellia) *funestus* Giles and *An. gambiae* s.l. are vectors of O'nyong nyong virus (ONNV) (Williams et al. 1965, Lutwama et al. 1999) and *Aedes* (*Diceromyia*) *taylori* Edwards is a vector of YFV (Monath 1988).

All species listed in Table 8 have previously been documented with naturally acquired infections of arboviruses of public health importance. These species may be involved in natural arbovirus cycles as principal or secondary epidemic vectors, primary or secondary enzootic vectors or as incidental vectors with unknown epidemiological importance. The presence of 50 mosquito species in western Uganda linked to a wide range of arboviruses suggests that there is the potential for maintenance and transmission of numerous arboviruses there, as well as the potential for outbreaks of arboviral diseases in this region. Field mosquito studies in Uganda are ongoing and are an important component of the arbovirus surveillance program. Eventually, the studies will include large areas in all provinces of the country. Our studies will update species lists for areas where the mosquito fauna has previously been described and will describe mosquito species compositions for areas where the diversity of the mosquito fauna is currently unknown. This mosquito species composition data will be invaluable in the future as a tool to predict the potential for emerging arboviral disease in Uganda.

Acknowledgements

We thank the Uganda Wildlife Authority for granting us access to Semliki National Park (SNP), Queen Elizabeth National Park (QENP), Bwindi Impenetrable National Park (BINP), Maramagambo Forest (MF) and Kibale National Park (KNP). We thank the park rangers at SNP, QENP, BINP, MF and KNP for their assistance and for use of UWA facilities. We thank T. Okello and M. Driciru for use of laboratory facilities at QENP. We thank C. Tumwesigye and A. Musinguzi for use of BINP and KNP facilities. We thank G. Kalema-Zikusoka, L. Zikusoka, S. Rubanga, H. Kumanya and other members of Conservation through Public Health (CTPH) for field assistance and for the use of CTPH facilities in BINP. We thank F. Ssenfunka, J.-B. Lwanga, S. Wakaalo J. Mugga, G. Kyazze and D. Ssemwogerere of UVRI, and K. Saxton-Shaw, J. Lederman and E. Borland of CDC Ft. Collins for field assistance during this project. We thank J. Pecor and Y.-M. Huang of the Smithsonian Institute for their assistance in verifying mosquito identifications. Lastly we thank Dr. R. Rosenberg for his assistance and support during this project. This study was supported in part by funds from USAID Emerging Pandemic Threat Program.

References Cited

(CDC) Centers for Diseases Control and Prevention. 2012Arbovirus Catalog (ARBOCAT). CDC, Fort Collins, CO http://wwwn.cdc.gov/arbocat/index.asp.

Corbet PS 1958 Identification of adult Mansonia (Coquillettidia) pseudoconopas Theobaldand Mansonia (Coquillettidia) maculipennis Theobald (Diptera: Culicidae). Proc. R. Entomol. Soc. Lond. 27: 127–128.

Corbet PS, Williams MC and Gillette JD. 1961 O'nyong-nyong fever: an epidemic virus disease in East Africa. IV. Vector studies at epidemic sites. Trans. R. Soc. Trop. Med. Hyg. 55: 463–480. [PubMed: 13881254]

Dick GWA and Haddow AJ. 1952 Uganda S virus a hitherto unrecorded virus isolated from mosquitoes in Uganda. Trans. R. Soc. Trop. Med. Hyg. 46: 600–618. [PubMed: 13005679]

Diallo M, Ba Y, Sall AA, Diop OM, Ndione JA, Mondo M, Girault L and Mathiot C. 2003 Amplification of the Sylvatic Cycle of Dengue Virus Type 2, Senegal, 1999–2000: Entomologic Findings and Epidemiologic Considerations. Emerg. Infect. Dis. 9: 362–367. [PubMed: 12643833]

Diallo M, Nabeth P, Ba K, Sall AA, Ba Y, Mondo M, Girault L, Abdalahi MO and Mathiot C. 2005 Mosquito vectors of the 1998–1999 outbreak of Rift Valley Fever and other arboviruses (Bagaza,

Sanar, Wesselsbron and West Nile) in Mauritania and Senegal. Med. Vet. Entomol. 19: 119–126. [PubMed: 15958020]

Edwards FW 1941 Mosquitoes of the Ethiopian Region. III. Culicine Adults and Pupae British Museum (Natural History), London.

Eilu G and Obua J. 2005 Tree condition and natural regeneration in disturbed sites of Bwindi Impenetrable Forest National Park, southwestern Uganda. Trop. Ecol. 46: 99–111.

Fontenille D, Traore-Lamizana M, Diallo M, Thonnon J, Digoutte JP and Zeller HG.1998 New vectors of Rift Valley fever in West Africa. Emerg. Infect. Dis. 4: 289–293. [PubMed: 9621201]

Germain M, Francy DB, Monath TP, Ferrara L, Bryan J, Salaun JJ, Heme G, Renaudet J, Adam C and Digoutte JP. 1980 Yellow fever in the Gambia, 1978—1979: entomological aspects and epidemiological correlations. Am. J. Trop. Med. Hyg. 29: 929–940. [PubMed: 7435794]

Gillett JD 1972 Notes on the subgenus Coquillettidia Dyar (Diptera, Culicidae). Bull. Entomol. Res. 36: 425–438.

Gillett JD 1972 Common African Mosquitoes and their Medical Importance. William Heinemann Medical Books Limited, London.

Gillies MT and De Mellion B. 1968 The Anophelinae of Africa South of the Sahara (Ethiopian Zoogeographical Region). The South African Institute for medical Research Johannesburg.

Gillies MT and Coetzee M. 1987 A supplement to the Anophelinae of Africa South ofthe Sahara (Afrotropical Region). The South African Institute for medical Research Johannesburg.

Gordon SW, Tammariello RF, Lithicum KJ, Dohm DJ,Digoutte JP, and Calvo-Wilson MA. 1992 Arbovirus isolation from mosquitoes collected during 1988 in the Senegal River Basin. Am. J. Trop. Med. Hyg. 47: 742–748. [PubMed: 1361722]

Gubler TP 1988 Dengue In, Monath TP (eds.), The Arboviruses: Epidemiology and Ecology. American Public Health Association, Washington D.C.

Haddow AJ 1945a On the mosquitoes of Bwamba County, Uganda. I Description of Bwamba with special reference to mosquito ecology. Proc. Zoo. Soc. Lond. 115: 1–13.

Haddow AJ 1945b The mosquitoes of Bwamba County, Uganda. II. Biting activity with special reference to the influence of microclimate. Bull. Entomol. Res. 36: 33–73.

Haddow AJ 1946 The mosquitoes of Bwamba County, Uganda. IV. Studies on the genus Eretmapodites Theobald. Bull. Entomol. Res. 37: 57–82.

Haddow AJ, Gillett JD and Highton RB. 1947 The mosquitoes of Bwamba County, Uganda. V. The vertical distribution and biting-cycle of mosquitoes in rain-forest, with further observations on microclimate. Bull. Entomol. Res. 37: 301–330. [PubMed: 20284933]

Haddow AJ, Smithburn KC, Dick GWA, Kitchen SF. and Lumsden WHR. 1948 Implication of the mosquito Aedes (Stegomyia) africanus Theobald in the forest cycle of yellow fever virus in Uganda. Ann. Trop. Med. Parasitol. 42: 218–223. [PubMed: 18891448]

Haddow AJ and Mahaffy AF. 1949 The mosquitoes of Bwamba County, Uganda. VII. Intensive catching on tree-platforms, with further observations on Aedes (Stegomyia) africanus Theobald. Bull. Entomol. Res. 40: 169–178. [PubMed: 18139173]

Haddow AJ and van Someren ECC. 1950 A new species of Stegomyia Theobald from the Ruwenzori range, Uganda. Ann. Trop. Med. Parasitol. 44:281–284. [PubMed: 24538830]

Haddow AJ, van Someren ECC, Lumsden WHR, Harper JO and Gillett JD. 1951 The mosquitoes of Bwamba County, Uganda. VIII. Records of occurrence, behavior and habitat. Bull. Entomol. Res. 42: 207–238.

Haddow AJ, Davies CW and Walker AJ. 1960 O'nyong-nyong fever: an epidemic virus disease in east Africa. I. Introduction. Trans. R. Soc. Trop. Med. Hyg. 54: 517–522.

Huang Y-M 1986 Aedes (Stegomyia) bromeliae (Diptera: Culicidae), the Yellow fever virus vector in East Africa. J. Med. Entomol. 23: 196–200. [PubMed: 3701804]

Huang Y-M 2004 The subgenus Stegomyia of Aedes in the Afrotropical Region with keys to the species (Diptera: Culicidae). Zootaxa. 700: 1–120.

Hubálek Z and Halouzka J. 1999 West Nile fever--a reemerging mosquito-borne viral disease in Europe. Emerg. Infect. Dis. 5: 643–650. [PubMed: 10511520]

Institut Pastuer de Dakar. 2000 Rapport Annuel. Organization Mondiale de la Sante Dakar, Senegal.

Jupp PG 1971 The taxanomic status of Culex (Culex) univittatus Theobald (Diptera: Culicidae) in South Africa. J. Entomol. Soc. S. Afric. 34: 339–357.

Jupp PG 1972 A morphological study of Culex (Culex) univittatus Theobald and Culex (Culex) neavei Theobald from various African countries. Mosq. Syst. 4: 103–113.

Jupp PG, Blackburn NK, Thompson DL and Meenehan GM. 1986 Sindbis and West Nile virus infections in the Witwatersrand-Pretoria region. S. Afric. Med. J. 70: 218–220

Jupp PG and McIntosh BM. 1988 Chikungunya a virus disease In, Monath TP (eds.), TheArboviruses: Epidemiology and Ecology. American Public Health Association, Washington D.C.

Jupp PG 1996 Mosquitoes of Southern Africa: Culicinae and Toxorhynchitinae. Ekoglide Publishers, Republic of South Africa.

Kakuru W 1993 Major Factors Influencing the Distribution of Tree Species in Bwindi Impenetrable National Park (BINP), Uganda. M.Sc. Thesis Makerere University, Kampala, Uganda.

Kibale National Park, Uganda. 2012 mailto:http://weber.ucsd.edu/~jmoore/apesites/Kibale/Kibale.html

Langdale-Brown I, Osmaston HA and Wilson JG. 1964 The Vegetation of Uganda and its Bearing on Land-Use. Government Printer, Entebbe.

Lee VH and Moore DL. 1972 Vectors of the 1969 yellow fever epidemic on the Jos Plateau, Nigeria. Bull. Wld. Hlth. Org. 46: 669–673.

Lock JM 1985 Recent changes in the vegetation of Queen Elizabeth National Park, Uganda. Afric. J. Ecol. 23: 63–65.

Lutwama JJ, Kayondo J, Savage HM, Burkot TR and Miller BR. 1999 Epidemic O'nyong-nyong fever in southcentral Uganda, 1996–1997: Entomologic studies in Bbaalevillage, Rakai District. Am. J. Trop. Med. Hyg. 61: 158–162. [PubMed: 10432073]

Mahaffy AF, Smithburn KC, Jacobs HR and Gillett JD. 1942 Yellow fever in western Uganda. Trans. R. Soc. Trop. Med. Hyg. 36: 9–20.

Marchette NJ, Garcia R and Rudnick AA. 1969 Isolation of Zika virus from Aedes aegypti mosquitoes in Malaysia. Am. J. Trop. Med. Hyg. 18: 411–415. [PubMed: 4976739]

McCrae AW and Kirya BG. 1982 Yellow fever and Zika virus epizootics and enzootics in Uganda. Trans. R. Soc. Trop. Med. Hyg. 76: 552–562. [PubMed: 6304948]

McIntosh BM, Brookworth C and Kokernot RH. 1961 Isolation of Semliki Forest virus from Aedes (Aedimorphus) argenteopunctatus (Theobald) collected in Portuguese East Africa. Trans. R. Soc. Trop. Med. Hyg. 55: 192–198. [PubMed: 13774007]

McIntosh BM, Jupp PG and De Sousa J. 1972 Further isolations of the arboviruses from mosquitoes collected in Tongaland, South Africa, 1960–1968. J. Med. Entomol. 9: 155–159. [PubMed: 4402531]

McIntosh BM 1986 Mosquito-borne virus diseases of man in southern Africa. S. Afric. Med. J. 70: 69–72.

Meegan JM and Bailey CL. 1988 Rift Valley Fever In, Monath TP (ed.), The Arboviruses: Epidemiology and Ecology. American Public Health Association, Washington D.C.

Monaghan AJ, MacMillan K, Moore SM, Mead PS, Mary MH. Hayden H and Eisen RJ. 2012 A regional climatography of West Nile, Uganda, to support human plague modelling. J. Appl. Met. Doi: 101175/Climat.JAMC-D-11-0195.

Monath TP 1988 Yellow Fever In, Monath TP (eds.), The Arboviruses: Epidemiology and Ecology. American Public Health Association, Washington D.C.

Mattingly PF 1957 Genetic aspects of the Aedes aegypti problem. I. Taxonomy and bionomics. Ann. Trop. Med. Parasitol. 51: 392–408. [PubMed: 13498658]

Namara A 2006 From Paternalism to Real Partnership with Local Communities? Experiences from Bwindi Impenetrable National Park (Uganda). Africa Development. XXXI: 39–68.

Simpson EH 1949 Measurement of diversity. Nature. 163: 688.

Smithburn KC and Haddow AJ. 1946 Isolation of yellow fever from African mosquitoes. Am. J. Trop. Med. Hyg. 26: 261–271. [PubMed: 20988053]

Smithburn KC, Mahaffy AF and Paul JH. 1941 Bwamba fever and its causative virus. Am. J. Trop. Med. Hyg. 21: 75–90.

Smithburn KC, Haddow AJ and Gillett JD. 1948 Rift valley virus: Isolation of the virus from wild mosquitoes. Brit. J. Exp. Path. 29: 107–121. [PubMed: 18868961]

Smithburn KC, Haddow AJ and Mahaffy AF. 1946 A neurotropic virus isolated from Aedes mosquitoes caught in the Semliki Forest. Am. J. Trop. Med. Hyg. 26: 189–208. [PubMed: 21020339]

Smithburn KC and Haddow AJ. 1951 Ntaya Virus: A hitherto unknown agent isolated from mosquitoes collected in Uganda. Proc. Soc. Exp. Biol. Med. 77: 130–133. [PubMed: 14844417]

Smithburn KC and Haddow AJ. 1944 Semliki Forest Virus. I. Isolation and pathogenic properties. J. Imm. 49: 141–157.

Traoré-Lamizana M, Fontenille D, Diallo M, Bâ Y, Zeller HG, Mondo M, Adam F, Thonon J and Maïga A. 2001 Arbovirus surveillance from 1990 to 1995 in the Barkedji area (Ferlo) of Senegal, a possible natural focus of Rift Valley fever virus. J. Med. Entomol. 38: 480–492. [PubMed: 11476327]

Weinbren MP and Hewitt LE. 1959 Virus neutralization tests on hippopotamus sera. East African Virus Research Institute Report July 1958 – June 1959 13–15.

Williams MC, Simpson DI, Haddow AJ and Knight EM. 1964 The isolation of West Nile virus from man and of Usutu virus from the bird-biting mosquito Mansonia aurites (Theobald) in the Entebbe area of Uganda. Ann. Trop. Med. Parasitol. 58: 367–374. [PubMed: 14212897]

Williams MC, Woodhall JP, Corbet PS and Gillett JD. 1965 O'nyong-nyong fever: An epidemic virus disease in East Africa VIII. Virus isolation from Anopheles mosquitoes. Trans. R. Soc. Trop. Med. Hyg. 59: 300–306. [PubMed: 14298035]

Woodhall JP 1964 The viruses isolated from arthropods at the East African Virus Research Institute in the 26 years ending December 1963. Proc. E. Afric. Acad. 2: 141–146.

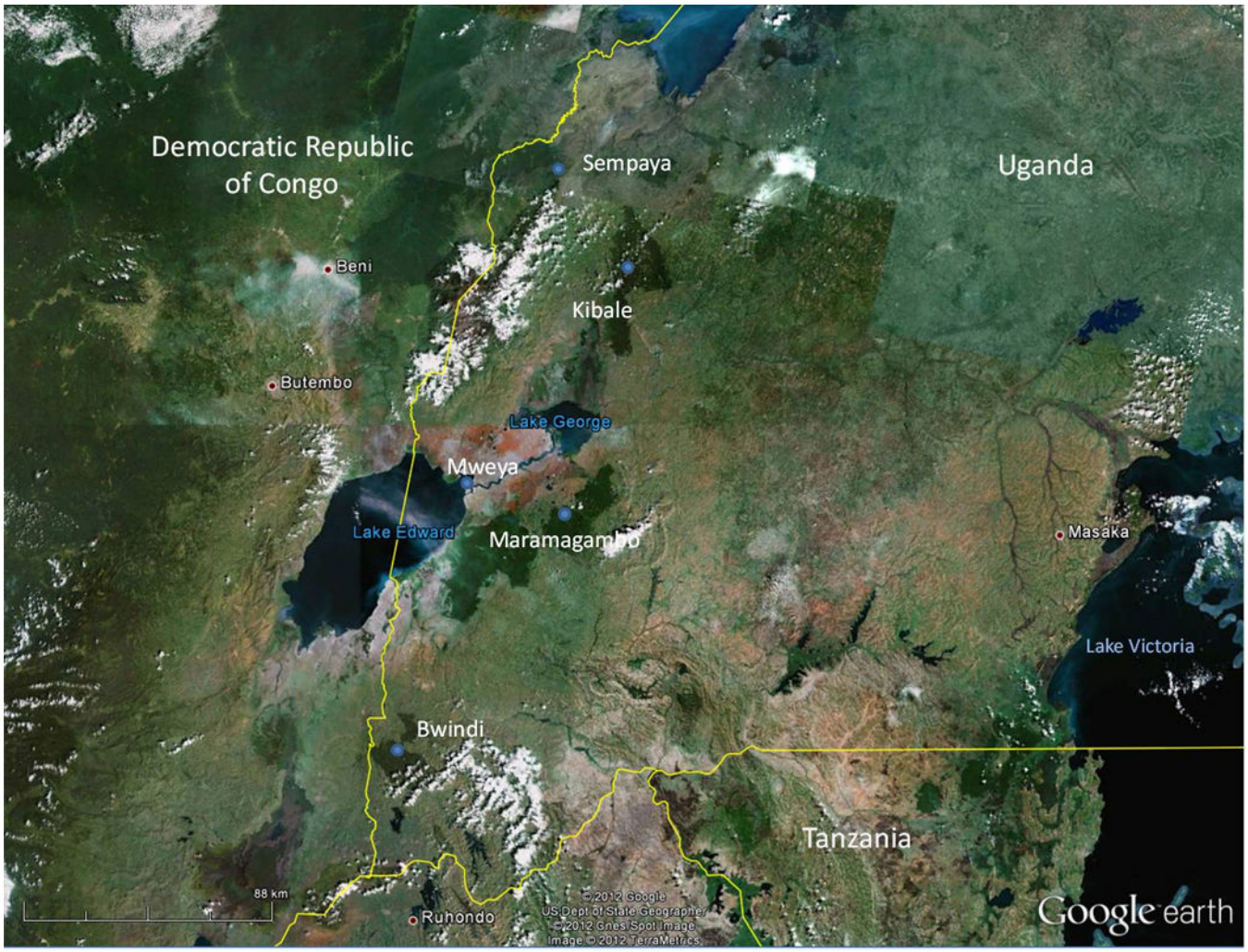

Fig. 1.

A map of Uganda showing the locations of Sempaya, in Semliki National Park, Mweya and Maramagambo Forest, in Queen Elizabeth National Park, Bwindi Impenetrable National Park and Kibale National Park in western Uganda.

Fig. 2.
Photographs illustrating the general vegetation and topology of each of the study sites A) Sempaya, B) Mweya, C) Maramagambo, D) Kibale and E) Bwindi.

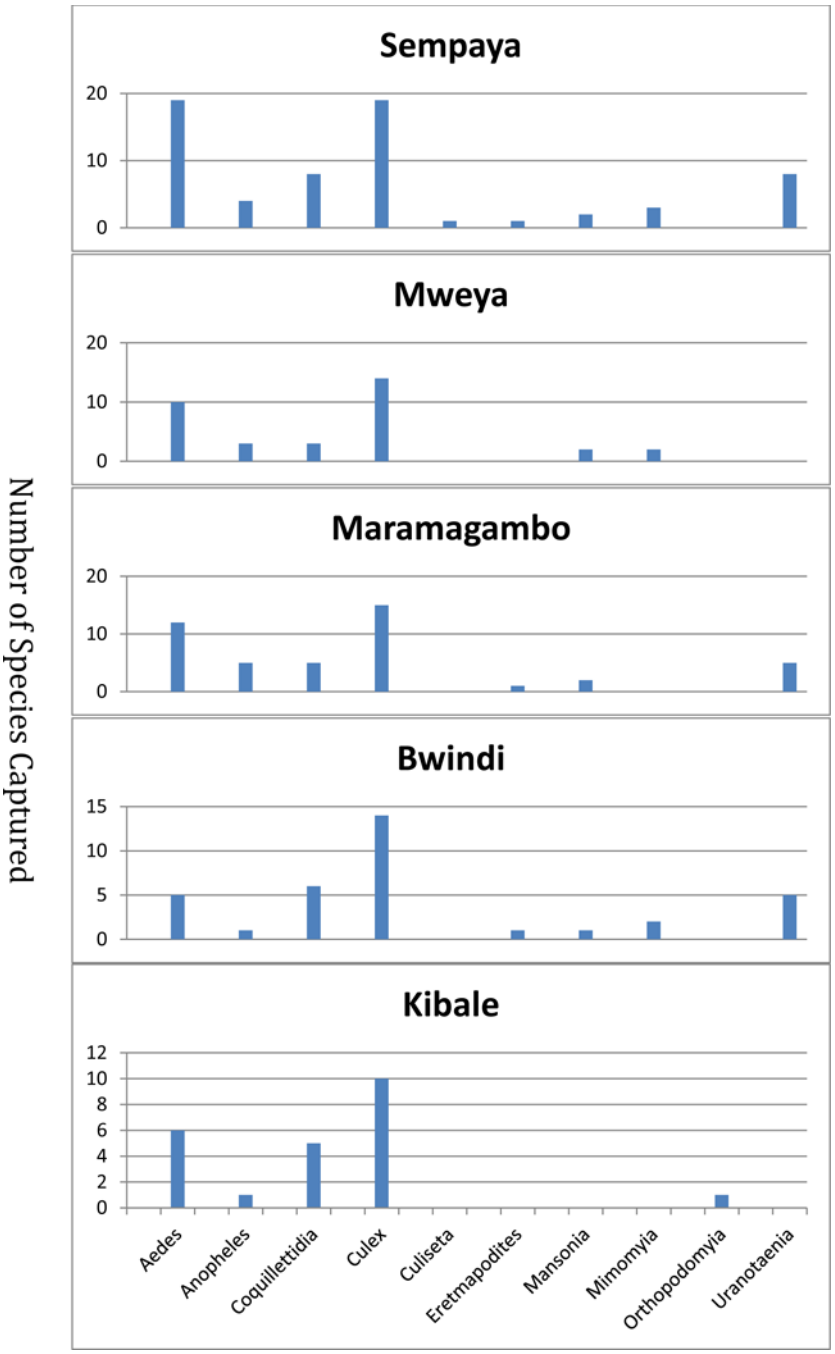

Fig. 3.
Number of mosquito species collected in each genus by study site.

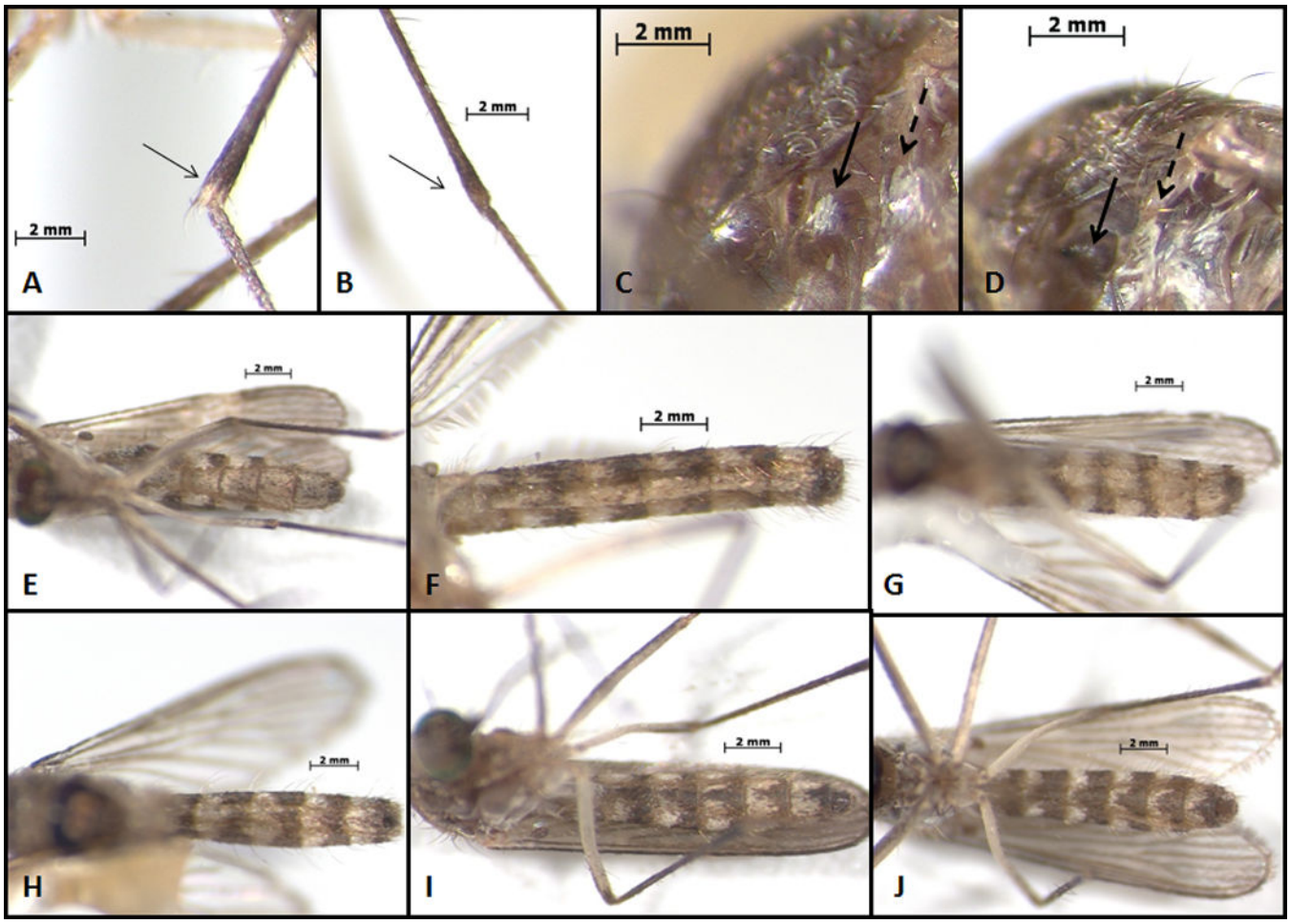

Fig. 4.

Morphological variations observed in the hind tibia (A-B), post-spiracular area (C-D) and sternum (E-J) of *Culex* (*Culex*) *neavei* Theobald from Uganda. A) Distinct white spot at the apex of the hind tibia. B) Indistinct white spot at the apex of the hind tibia. C) Post-spiracular scales present (solid arrow); pre-alar scales (dashed arrow). D) Post-spiracular scales absent (solid arrow); pre-alar scales (dashed arrow). E) Sternites pale. F) Sternites pale with a few black scales medially. G) Sternites pale with narrow black apical bands. H) Sternites pale with wide black apical bands. I) Sternites with median apical black triangles. J) Sternites mostly black with pale scales along basal and lateral margins.

Table 1.

Number of mosquito species and subspecies collected at five locations in western Uganda from 2008 to 2010.

Genus	Subgenus	Species	Collection Site				
			Bwindi	Kibale	Maramagambo	Mweya	Sempaya
Aedes	*Aedimorphus*	*abnormalis kabwachensis* Edwards				4	
		albocephalus (Theobald)			117	28	1007
		argenteopunctatus (Theobald)				1	
		cumminsii (Theobald)	6	1	115	2	585
		domesticus (Theobald)					17
		hirsutus (Theobald)				2	1
		leptolabis Edwards					1
		mutilus Edwards			2		1
		natronius Edwards				19	7
		quasiunivittatus (Theobald)		2			
		stenoscutus Edwards					29
		stokesi Evans					8
		tarsalis (Newstead)	15	117	5		405
		tricholabis Edwards			1		
	Diceromyia	*taylori* Edwards			1		
	Finlaya	*ingrami* Edwards	1	4			5
	Mucidus	*grahamii* (Theobald)					3
	Neomelaniconion	*albothorax* (Theobald)			3	19	1601
		circumluteolus (Theobald)	11	18	334	20	281
		mcintoshi Huang				1	
		palpale Newstead	1				
		taeniarostris (Theobald)			1		6
		taeniarostris/carteri			1		
	Stegomyia	*aegypti* Linnaeus		1		6	6
		aegypti formosus (Walker)		1		39	24
		apicoargenteus group[1]		2			3

Genus	Subgenus	Species	Collection Site				
			Bwindi	Kibale	Maramagambo	Mweya	Sempaya
		dendrophilus group[2]			1		15
		fraseri (Edwards)			7		
		luteocephalus (Newstead)			1		1
		metallicus (Edwards)				68	16
		simpsoni group[3]				6	17
Aedes		species				32	14
	Zavortinkius	*longipalpis* (Gruenberg)			1		1
Aedes		*species*				2	13
Anopheles	*Anopheles*	*coustani* Laveran			1		
		implexus (Theobald)	3	60	11		
		obscurus (Gruenberg)			1		1
		paludis Theobald					8
		symesi Edwards				166	
		ziemanni Greunberg			1	74	
	Cellia	*demeilloni* Evans					2
		domicola Edwards			5		
		funestus group[4]			1		1
		gambiae group[5]			1	11	413
		longipalpis/funestus					2
		pharoensis Theobald				3	
		rivulorum Leeson					5
Anopheles		species			4	7	
Coquillettidia	*Coquillettidia*	*aureus* (Edwards)					1
		aurites (Theobald)	60		20		22
		fraseri (Theobald)	483	123		7	29
		aurites/fraseri					5
		fuscopennata (Theobald)		564	371		370
		maculipennis (Theobald)	96	1119	29		227
		metallica (Theobald)	2		72	164	94

Genus	Subgenus	Species	Collection Site				
			Bwindi	Kibale	Maramagambo	Mweya	Sempaya
		microannulata (Theobald)			2		1
		pseudoconopas (Theobald)	47	85		2	1516
		versicolor (Edwards)	3	96			
		species	2		2		7
Culex	*Culex*	*antennatus* (Becker)	2	3	5	307	34
		decens group[6]	240	285	51	1	190
		duttoni Theobald			1	63	1
		ingrami Edwards		3	1		
		neavei Theobald	13		165	14751	139
		omatothoracis Theobald					1
		perfuscus Edwards			2		11407
		pipiens complex[7]	5				7
		pipiens Linnaeus	1				
		pruina Theobald	1		60		
		quasiguiarti Theobald	1				7
		quinquefasciatus Say	4			5	33
		terzii Edwards				2	
		toroensis macrophyllus Edwards & Gibbins	1				
		trifilatus Edwards	74	15			
		trifilatus aenescens Edwards	84	107			
		watti Edwards	1	25		1	2
		zombaensis Theobald			10	5	
	Culiciomyia	*cinerellus* Edwards			1		
		cinereus Theobald	14			143	13
		macfiei Edwards		2			
		mongiro Van Someren			4		87
		nebulosus Theobald	81	45	8		193
	Eumelanomyia	*horridus* Edwards					15
		insignis (Carter)	1		7	8	11

Genus	Subgenus	Species	Collection Site				
			Bwindi	Kibale	Maramagambo	Mweya	Sempaya
		rubinotus Theobald		3		20	37
		simpliciforceps Edwards		31			
	Kitzmilleria	*moucheti* Evans	28		13		65
	Lutzia	*tigripes* De Grandpre & De Charmoy	4	4	2	2	11
	Oculeomyia	*annulioris* Theobald	39	10	4	4	51
		annulioris consimilis Newstead	257	140			
		aurantapex jinjaensis Edwards		9			
		poicilipes (Theobald)			2	19710	337
Culex		species	100	47	68	9	1590
Culiseta	*Theomyia*	*fraseri* Edwards					2
Eretmapodites		*chrysogaster* Graham	1		2		329
Mansonia	*Mansonioides*	*africana* (Theobald)			35	801	56
		africana nigerrima Theobald	4		1		
		uniformis (Theobald)			1	2162	7
Mimomyia	*Etorleptiomyia*	*mediolineata* (Theobald)				1	23
	Mimomyia	*hispida* (Theobald)	1				
		mimomyiaformis (Newstead)				359	1
		plumosa (Theobald)	1				20
Orthopodomyia		species		2			
Uranotaenia	*Pseudoficalbia*	*mashonaensis* Theobald	2		5		925
		musarum Edwards			3		16
		nivipous Theobald					10
	Uranotaenia	*alboabdominalis* Theobald			1		8
		balfouri Theobald	1				1
		chorleyi Edwards	3				11
		connali Edwards	1		3		84
		pallidocephala Theobald	10		1		3
Totals			**1705**	**2924**	**1567**	**39037**	**22498**

[1]The *Ae. apicoargenteus* group includes *Ae. apicoargenteus s.s.* (Theobald), *Ae. blacklocki* (Evans), *Ae. denderensis* Wolfs, *Ae. ealaensis* Huang, *Ae. fraseri* (Edwards), *Ae. schwetzi* Edwards & *Ae. soleatus* Edwards (Huang 2004).

[2]The *Ae. dendrophilus* group includes *Ae. amaltheus* De Meillon & Lavoipierre, *Ae. bambusae* Edward, *Ae. deboeri* Edwards, *Ae. demeilloni* Edwards, *Ae. dendrophilus s.s.* Edwards, *Ae. hansfordi* Huang, *Ae. heischi* Van Someren, *Ae. keniensis* Van Someren, *Ae. kenyae* Van Someren & *Ae. masseyi* Edwards (Huang 2004).

[3]The *Ae. simpsoni* group includes *Ae. simpsoni* s.s. (Theobald), *Ae. bromeliae* (Theobald), *Ae. gandaensis* Huang, *Ae. josiahae* Huang, *Ae. kivuensis* Edwards, *Ae. lilii* (Theobald), *Ae. strelitziae*, Muspratt, *Ae. subargenteus* Edwards & *Ae. woodi* Edwards (Huang 2004).

[4]The *Anopheles funestus* group includes *An. funestus s.s.*, *An. rivulorum* Leeson, *An. leesoni* Evans, *An. vaneedeni* Gillies & Coetzee, *An. parensis* Gillies, *An. confusus* Evans & Leeson, *An. aruni* Sobti, *An. fuscivenosus* Leeson, and *An. brucei* Service (Gilles & Coetzee 1987).

[5]The *Anopheles gambiae* group consist of at least 6 species *An. gambiae s.s.* Giles, *An. arabiensis* Patton, *An. quadriannulatus* Theobald, *An. melas* Theobald, *An. merus* Dönitz & *An. bwambae* White (Gilles & Coetzee 1987).

[6]The *Culex decens* group includes *Cx. decens* Theobald & *Cx. invidiosus* Theobald (Edwards 1941).

[7]In sub-Saharan Africa the *Culex pipiens* complex consists of *Cx. pipiens* Linneaus & *Cx. quinquefasciatus* Say (Edwards 1941).

Table 2.

Mosquito species collected at Sempaya, Semliki National Park, Uganda, in November 2008, June 2009 and January 2010. Simpson's Index (D) and Simpson's Index of Diversity (1-D) for each collection trip are presented at the bottom of the table.

			Number collected (%)					
Genus	**Subgenus**	**Species**	**November 2008**		**June 2009**		**January 2010**	
Aedes	*Aedimorphus*	*albocephalus*	6	(0.14)	901	(5.43)	100	(6.54)
		cumminsii	5	(0.11)	576	(3.47)	4	(0.26)
		domesticus			13	(0.08)	4	(0.26)
		hirsutus			1	(0.01)		
		leptolabis			1	(0.01)		
		mutilus			1	(0.01)		
		natronius			6	(0.04)	1	(0.07)
		stenoscutus			29	(0.17)		
		stokesi			7	(0.04)	1	(0.07)
		tarsalis	17	(0.39)	344	(2.07)	44	(2.88)
	Finlaya	*ingrami*			5	(0.03)		
	Mucidus	*grahamii*			3	(0.02)		
	Neomelaniconion	*albothorax*	94	(2.15)	1309	(7.88)	198	(12.96)
		circumluteolus	77	(1.76)	154	(0.93)	50	(3.27)
		taeniarostris			6	(0.04)		
	Stegomyia	*aegypti*			6	(0.04)		
		aegypti formosus			21	(0.13)	3	(0.20)
		apicoargenteus group[1]			1	(0.01)	2	(0.13)
		dendrophilus group[2]			15	(0.09)		
		luteocephalus			1	(0.01)		
		metallicus			16	(0.10)		
		simpsoni group[3]			17	(0.10)		
		species			13	(0.08)	1	(0.07)
	Zavortinkus	*longipalpis*			1	(0.01)		

Genus	Subgenus	Species	Number collected (%) November 2008		June 2009		January 2010	
Aedes		species	6	(0.14)			7	(0.46)
Anopheles	*Anopheles*	*obscurus*			1	(0.01)		
		paludis			8	(0.05)		
	Cellia	*demeilloni*			2	(0.01)		
		gambiae group[5]	79	(1.81)	206	(1.24)	128	(8.38)
		funestus group[4]					1	(0.07)
		longipalpis/funestus			2	(0.01)		
		rivulorum			5	(0.03)		
Coquillettidia	*Coquillettidia*	*aureus*			1	(0.01)		
		aurites			14	(0.08)	8	(0.52)
		fraseri			27	(0.16)	2	(0.13)
		aurites/fraseri	5	(0.11)		(0.00)		
		fuscopennata	50	(1.15)	189	(1.14)	131	(8.57)
		maculipennis	8	(0.18)	208	(1.25)	11	(0.72)
		metallica	3	(0.07)	58	(0.35)	33	(2.16)
		microannulatus			1	(0.01)		
		pseudoconopas	56	(1.28)	1401	(8.44)	59	(3.86)
Coquillettidia		species	7	(0.16)				
Culex	*Culex*	*antennatus*			34	(0.20)		
		decens group[6]	9	(0.21)	163	(0.98)	18	(1.18)
		duttoni					1	(0.07)
		neavei	3	(0.07)	97	(0.58)	39	(2.55)
		ornatothoracis			1	(0.01)		
		perfuscus	3429	(78.59)	7839	(47.20)	139	(9.10)
		pipiens			7	(0.04)		
		quasiguiarti				(0.00)	7	(0.46)
		quinquefasciatus			33	(0.20)		
		watti	1	(0.02)			1	(0.07)

Genus	Subgenus	Species	Number collected (%)					
			November 2008		June 2009		January 2010	
	Culiciomyia	*cinereus*			12	(0.07)	1	(0.07)
		mongiro	61	(1.40)	24	(0.14)	2	(0.13)
		nebulosus	8	(0.18)	131	(0.79)	54	(3.53)
	Eumelanomyia	*horridus*	2	(0.05)	13	(0.08)		
		insignis	2	(0.05)	5	(0.03)	4	(0.26)
		rubinotus	36	(0.83)			1	(0.07)
	Kitzmilleria	*moucheti*	1	(0.02)	37	(0.22)	27	(1.77)
	Lutzia	*tigripes*	2	(0.05)	8	(0.05)	1	(0.07)
	Oculeomyia	*annulioris*			50	(0.30)	1	(0.07)
		poicilipes	335	(7.68)	2	(0.01)		
Culex		species	5	(0.11)	1545	(9.30)	40	(2.62)
Culiseta	*Theomyia*	*fraseri*					2	(0.13)
Eretmapodites		*chrysogaster*	13	(0.30)	16	(0.10)	300	(19.63)
Mansonia	*Mansonioides*	*africana*	1	(0.02)	42	(0.25)	13	(0.85)
		uniformis	6	(0.14)	1	(0.01)		
Mimomyia	*Etorleptiomyia*	*mediolineata*			18	(0.11)	5	(0.33)
	Mimomyia	*mimomyiaformis*					1	(0.07)
		plumosa	18	(0.41)	2	(0.01)		
Uranotaenia	*Pseudoficalbia*	*mashonaensis*			870	(5.24)	55	(3.60)
		musarum	7	(0.16)	7	(0.04)	2	(0.13)
		nivipous			7	(0.04)	3	(0.20)
	Uranotaenia	*alboabdominalis*	1	(0.02)	4	(0.02)	3	(0.20)
		balfouri			1	(0.01)		
		chorleyi	10	(0.23)	1	(0.01)		
		connali			65	(0.39)	19	(1.24)
		pallidocephala			2	(0.01)	1	(0.07)
Totals			4363		16607		1528	
Grand Total:		22,498						

Genus	Subgenus	Species	Number collected (%)		
			November 2008	June 2009	January 2010
D			0.63	0.25	0.09
1-D			0.37	0.75	0.91

1–6 refer to footnotes of table 1.

Table 3.

Mosquito species collected at Mweya, Queen Elizabeth National Park, Uganda, in November 2008, June 2009 and January 2010. Simpson's Diversity Index (D) and Simpson's Index of Diversity (1-D) for each collection trip are presented at the bottom of the table.

			Number collected (%)					
Genus	**Subgenus**	**Species**	**November 2008**		**June 2009**		**January 2010**	
Aedes	*Aedimorphus*	*abnormalis kabwachensis*	1	(0.01)	2	(0.01)	1	(0.01)
		albocephalus	1	(0.01)	22	(0.11)	5	(0.05)
		argenteopunctatus	1	(0.01)				
		cumminsii					2	(0.02)
		hirsutus			2	(0.01)		
		natronius					19	(0.20)
	Neomelaniconion	*albothorax*			9	(0.04)	10	(0.11)
		circumluteolus			16	(0.08)	4	(0.04)
		mcintoshi	1	(0.01)				
	Stegomyia	*aegypti*			6	(0.03)		
		aegypti formosus	18	(0.21)	17	(0.08)	4	(0.04)
		metallicus	44	(0.51)	17	(0.08)	7	(0.07)
		simpsoni group[3]			6	(0.03)		
		(Stegomyia) species	9	(0.10)	14	(0.07)	9	(0.10)
Aedes		species					2	(0.02)
Anopheles	*Anopheles*	*symesi*	2	(0.02)	9	(0.04)	155	(1.64)
		ziemanni	1	(0.01)	13	(0.06)	60	(0.63)
	Cellia	*gambiae group*[5]	3	(0.03)	6	(0.03)	2	(0.02)
		pharoensis			2	(0.01)	1	(0.01)
Anopheles		species			1	(0.00)	6	(0.06)
Coquillettidia	*Coquillettidia*	*fraseri*			4	(0.02)	3	(0.03)
		metallica	1	(0.01)	123	(0.59)	40	(0.42)
		pseudoconopas			2	(0.01)		
Culex	*Culex*	*antennatus*			230	(1.10)	77	(0.81)

Genus	Subgenus	Species	Number collected (%)					
			November 2008		June 2009		January 2010	
		decens group[6]					1	(0.01)
		duttoni			54	(0.26)	9	(0.10)
		neavei	1661	(19.14)	10038	(48.06)	3052	(32.22)
		quinquefasciatus	1	(0.01)	2	(0.01)	2	(0.02)
		terzii			2	(0.01)		
		watti					1	(0.01)
		zombaensis			4	(0.02)	1	(0.01)
	Culiciomyia	*cinereus*	5	(0.06)	117	(0.56)	21	(0.22)
	Eumelanomyia	*insignis*			5	(0.02)	3	(0.03)
		rubinotus	1	(0.01)	1	(0.00)	18	(0.19)
	Lutzia	*tigripes*			2	(0.01)		
	Oculeomyia	*annulioris*			4	(0.02)		
		poicilipes	6316	(72.78)	9287	(44.46)	4107	(43.36)
Culex		species					9	(0.10)
Mansonia	*Mansonioides*	*africana*	76	(0.88)	196	(0.94)	529	(5.59)
		uniformis	499	(5.75)	476	(2.28)	1187	(12.53)
Mimomyia	*Etorleptiomyia*	*mediolineata*			1	(0.00)		
	Mimomyia	*mimomyiaformis*	37	(0.43)	198	(0.95)	124	(1.31)
			8,678		20,888		9,471	
Grand Total:	39,037							
D			0.57		0.43		0.31	
1-D			0.43		0.57		0.69	

3, 5 & 6 refer to the footnotes of table 1.

Table 4.

Mosquito species collected at Maramagambo, Queen Elizabeth National Park, Uganda, in June 2009 and January 2010. Simpson's Index (D) and Simpson's Index of Diversity (1-D) for each collection trip are presented at the bottom of the table.

			Number collected (%)			
			June 2009		January 2010	
Genus	**Subgenus**	**Species**				
Aedes	*Aedimorphus*	*albocephalus*	11	(1.94)	106	(10.60)
		cumminsii	17	(3.00)	98	(9.80)
		mutilus			2	(0.20)
		tarsalis	1	(0.18)	4	(0.40)
		tricholabis	1	(0.18)		
	Diceromyia	*taylori*	1	(0.18)		
	Neomelaniconion	*albothorax*	1	(0.18)	2	(0.20)
		circumluteolus	277	(48.85)	57	(5.70)
		taeniarostris			1	(0.10)
		taeniarostris/carteri			1	(0.10)
	Stegomyia	*dendrophilus* group[2]			1	(0.10)
		fraseri	5	(0.88)	2	(0.20)
		luteocephalus	1	(0.18)		
	Zavortinkus	*longipalpis*			1	(0.10)
Anopheles	*Anopheles*	*coustani*	1	(0.18)		
		implexus			11	(1.10)
		obscurus			1	(0.10)
		ziemanni			1	(0.10)
	Cellia	*domicola*			5	(0.50)
		funestus group[4]	1	(0.18)		
		gambiae group[5]	1	(0.18)		
Anopheles		species			4	(0.40)
Coquillettidia	*Coquillettidia*	*aurites*	9	(1.59)	11	(1.10)
		fuscopennata	141	(24.87)	230	(23.00)

Genus	Subgenus	Species	Number collected (%) June 2009		Number collected (%) January 2010	
		maculipennis	1	(0.18)	28	(2.80)
		metallica	11	(1.94)	61	(6.10)
		microannulata	2	(0.35)		
Coquillettidia		species			2	(0.20)
Culex	*Culex*	*antennatus*	4	(0.71)	1	(0.10)
		decens group[6]	7	(1.23)	44	(4.40)
		duttoni	1	(0.18)		
		ingrami			1	(0.10)
		neavei	7	(1.23)	158	(15.80)
		perfuscus	2	(0.35)		
		pruina			60	(6.00)
		zombaensis	10	(1.76)		
	Culiciomyia	*cinerellus*	1	(0.18)		
		mongiro	2	(0.35)	2	(0.20)
		nebulosus	8	(1.41)		
	Eumelanomyia	*insignis*	3	(0.53)	4	(0.40)
	Kitzmilleria	*moucheti*	7	(1.23)	6	(0.60)
	Lutzia	*tigripes*	2	(0.35)		
	Oculeomyia	*annulioris*	1	(0.18)	3	(0.30)
		poicilipes	2	(0.35)		
Culex		species	15	(2.65)	53	(5.30)
Eretmapodites		*chrysogaster*	2	(0.35)		
Mansonia	*Mansonioides*	*africana*	4	(0.71)	31	(3.10)
		africana nigerrima	1	(0.18)		
		uniformis	1	(0.18)		
Uranotaenia	*Pseudoficalbia*	*mashonaensis*			5	(0.50)
		musarum	2	(0.35)	1	(0.10)
	Uranotaenia	*alboabdominalis*	1	(0.18)		
		connali	2	(0.35)	1	(0.10)

J Med Entomol. Author manuscript; available in PMC 2019 May 26.

Genus	Subgenus	Species	Number collected (%) June 2009	Number collected (%) January 2010
		pallidocephala		1 (0.10)
			567	1000
Grand Total:	1,567			
D			0.30	0.12
1-D			0.70	0.88

2, 4, 5 & 6 refer to the footnotes of table 1.

Table 5.

Mosquito species collected at Bwindi Impenetrable Forest, Uganda, in January and June 2010. Simpson's Index (D) and Simpson's Index of Diversity (1-D) for each collection trip are presented at the bottom of the table.

			Number collected (%)			
Genus	**Subgenus**	**Species**	**January 2010**		**June 2010**	
Aedes	*Aedimorphus*	*cumminsii*			6	(0.6)
		tarsalis	10	(1.5)	5	(0.5)
	Finlaya	*ingrami*			1	(0.1)
	Neomelaniconion	*circumluteolus*			11	(1.1)
		palpale			1	(0.1)
Anopheles	*Anopheles*	*implexus*	3	(0.4)		
Coquillettidia	*Coquillettidia*	*aurites*	23	(3.4)	37	(3.6)
		fraseri	214	(31.2)	269	(26.4)
		maculipennis	53	(7.7)	43	(4.2)
		metallica	1	(0.1)	1	(0.1)
		pseudoconopas	7	(1.0)	40	(3.9)
		versicolor			3	(0.3)
Aedes		species	2	(0.3)		
Culex	*Culex*	*antennatus*			2	(0.2)
		decens group[6]	115	(16.8)	125	(12.3)
		neavei			13	(1.3)
		pipiens			1	(0.1)
		pipiens/quinquefasciatus	5	(0.7)		
		quasiguiarti			1	(0.1)
		quinquefasciatus			4	(0.4)
		pruina	1	(0.1)		
		toroensis macrophyllus	1	(0.1)		
		trifilatus	1	(0.1)	73	(7.2)
		trifilatus aenescens	2	(0.3)	82	(8.1)
		watti	1	(0.1)		
	Culiciomyia	*cinereus*	9	(1.3)	3	(0.3)

Genus	Subgenus	Species	Number collected (%)			
			January 2010		June 2010	
		nebulosus	45	(6.6)	38	(3.7)
	Eumelanomyia	*insignis*			1	(0.1)
	Kitzmilleria	*moucheti*	10	(1.5)	18	(1.8)
	Lutzia	*tigripes*	3	(0.4)	1	(0.1)
	Oculeomyia	*annulioris*	29	(4.2)	10	(1.0)
		annulioris consimilis	81	(11.8)	176	(17.3)
Culex		species	58	(8.5)	42	(4.1)
Eretmapodites		*chrysogaster*			1	(0.1)
Mansonia	*Mansonioides*	*africana nigerrima*			4	(0.4)
Mimomyia	*Mimomyia*	*hispida*			1	(0.1)
		plumosa			1	(0.1)
Uranotaenia	*Pseudoficalbia*	*mashonaensis*			2	(0.2)
	Uranotaenia	*balfouri*			1	(0.1)
		chorleyi	3	(0.4)		
		connali			1	(0.1)
		pallidocephala	10	(1.5)		
Totals			687		1,018	
Grand Total:	1,705					
D			0.16		0.13	
1-D			0.84		0.87	

[6] refer to footnotes on table 1.

Table 6.

Mosquito species collected at Kibale National Park, Uganda, in June 2010. Simpson's Index (D) and Simpson's Index of Diversity (1-D) are presented at the bottom of the table.

			Number collected (%)	
			June 2010	
Genus	**Subgenus**	**Species**		
Aedes	*Aedimorphus*	*cumminsii*	1	(0.03)
		quasiunivittatus	2	(0.07)
		tarsalis	117	(4.00)
	Finlaya	*ingrami*	4	(0.10)
	Neomelaniconion	*circumluteolus*	18	(0.62)
	Stegomyia	*aegypti*	1	(0.03)
		aegypti formosus	1	(0.03)
		apicoargenteus group[1]	2	(0.07)
Anopheles	*Anopheles*	*implexus*	60	(2.05)
Coquillettidia	*Coquillettidia*	*fraseri*	123	(4.21)
		fuscopennata	564	(19.29)
		maculipennis	1119	(38.27)
		pseudoconopas	85	(2.91)
		versicolor	96	(3.28)
Culex	*Culex*	*antennatus*	3	(0.10)
		decens group[6]	285	(9.75)
		neavei	3	(0.10)
		trifilatus	15	(0.51)
		trifilatus aenescens	107	(3.66)
		watti	25	(0.85)
	Culiciomyia	*macfiei*	2	(0.07)
		nebulosus	45	(1.54)
	Eumelanomyia	*rubinotus*	3	(0.10)
		simpliciforceps	31	(1.06)
	Lutzia	*tigripes*	4	(0.10)
	Oculeomyia	*annulioris*	10	(0.34)
		annulioris consimilis	140	(4.79)
		aurantapex jinjaensis	9	(0.31)
Culex		species	47	(1.61)
Orthopodomyia		species	2	(0.07)
Grand Total			2,924	
D			0.20	
1-D			0.80	

1 & 6 refer to footnotes on table 1.

Table 7.

Morphological variations in *Culex* (*Culex*) *neavei* from Uganda. Each row of checkmarks for Bwindi, Kibale, Maramagambo, Mweya, and Semliki (Sempaya) represents the characters present on a single specimen from this study. References 1 – 4 list the character combinations noted in previous studies.

	Morphological character				
Location	**Post-spiracular scales**		**White spot at apex of hind tibia**		**Sternites**
	Present	**Absent**	**Distinct**	**Indistinct**	
throughout Africa[1]		√		√	pale
Bwamba County, Uganda[2]	√	√	√	√	sometimes with dark scales (several variations listed)
South Africa[3]	√		√		dark apical lateral triangles; sometimes has dark scales medially
throughout Africa[4]	√		√		dark apical lateral triangles sometimes absent
Bwindi	√			√	pale
	√		√		pale with dark medial apical triangles
	√		√		pale with dark scales medially
Kibale	√		√		mostly dark; white scales only on basal margins
Maramagambo	√			√	pale with dark medial apical triangles
	√			√	pale
	√		√		pale with dark medial apical triangles
	√		√		pale with dark scales medially
Mweya	√			√	pale
	√			√	pale with dark medial apical triangles
	√		√		pale with dark scales medially
		√		√	pale with dark scales medially
		√	√		pale with dark scales medially
Semliki		√	√		pale with dark medial apical triangles
	√			√	pale
	√		√		pale with dark scales along apical margin
	√			√	pale with dark scales along apical margin
	√		√		pale with dark scales medially
	√		√		pale

[1] Edwards (1941)

[2] Haddow et al. (1951)

[3] Jupp (1971)

[4] Jupp (1972)

Table 8.

Mosquito species collected in western Uganda from which arboviruses of medical importance have previously been isolated. The list shows some of the medically important arboviruses previously isolated from each species.

Genus	Subgenus	Species	Arbovirus(es)
Aedes	*Aedimorphus*	*abnormalis*	MIDV[1], PGAV[1], SFV[1, 4], SPOV[1, 5], WSLV[1, 5], CHIKV[5]
		albocephalus	MIDV[1], WNV[1, 19]
		argenteopunctatus	BUNV[1, 5], MIDV[1, 5], PGAV[1, 5], SFV[1, 4, 18], SHOV[1, 5], WSLV[1, 5], CHIKV[5], NRIV[5]
		cumminsii	DENV-2[1, 5], MIDV[1, 3, 5], PGAV[1, 5], RVFV[1, 2, 5, 20], SHOV[1, 3], SPOV[1, 4, 5], WSLV[1, 5], SINV[3] CHIKV[5]
		domesticus	WSLV[1, 5], BUNV[5]
		mutilus	CHIKV[5]
		tarsalis	MIDV[1, 5], PGAV[1], SHOV[1, 5], WSLV[1, 5], ZIKAV[1, 5], RVFV[2, 17]
	Diceromyia	*taylori*	DENV-2[1, 5, 22], YFV[1, 5, 6], CHIKV[5], ZIKAV [5], ORUV[5]
	Finlaya	*ingrami*	CHIKV[5]
	Mucidus	*grahami*	CHIKV[5], ZIKAV[5]
	Neomelaniconion	*albothorax*	WNV[1, 5]
		circumluteolus	BUNV[1], GERV[1], LEBV[1], MIDV[1, 4], PGAV[1, 5], RVFV[1], SHOV[1], SPOV[1], WSLV[1, 4, 5], WNV[1, 5, 19]
		mcintoshi	RVFV[8], WSLV[5], NRIV[5]
		taeniarostris	CHIKV[5], ZIKAV[5], WSLV[5]
	Stegomyia	*aegypti*	CHIKV[1, 5], DENV-1[1], DENV-2[1, 22], DENV-3[1], DENV-4[1], DUGV[1], ORUV[1, 5], USUV[1], VEEV[1], WNV[1, 5, 19], YFV[1, 5, 8, 21], ZIKAV[1, 5, 23], SFV[5], WSLV[5], BBKV[5]
		apicoargenteus	ZIKAV[7]
		dendrophilus	RVFV[2, 10]
		luteocephalus	CHIKV[1, 5], DENV-2[1, 5, 22], PGAV[1, 5], YFV[5, 6], ZIKAV[1, 5, 24], WSLV[5]
		metallicus	YFV[5, 6], WSLV[5], ZIKAV[5]
		simpsoni group	YFV[6, 13, 14], BBKV[5], NRIV[5]

J Med Entomol. Author manuscript; available in PMC 2019 May 26.

Genus	Subgenus	Species	Arbovirus(es)
Anopheles	*Anopheles*	*coustani*	CHIKV[1, 5], PGAV[1, 5], WNV[1, 19], NRIV[5]
	Cellia	*demicola*	WSLV[5]
		funestus complex	BWAV[1, 5, 24], CHIKV[1, 5], ONNV[1, 5, 9, 15, 16], ORUV[1, 5], PGAV[1, 5], SFV[1, 4], WSLV[1, 5], TATV[5], NDOV[5], TATV[4, 5]
		gambiae s.l.	BWAV[1, 5], CHIKV[1], ILEV[1, 5], MIDV [1, 5], ONNV[1, 5, 15, 16], ORUV[1, 5], ZIKAV[1, 5], TATV[5], NRIV[5], NDOV[5], BGIV[5], TATV[4, 5]
		pharoensis	SINV[1], WSLV[5], NRIV[5], BGIV[5]
Coquillettidia	*Coquillettidia*	*aurites*	USUV[1], TATV[4, 5]
		fuscopennata	SINV[1, 10], CHIKV[10], YFV[1, 6]
		maculipennis	CHIKV[5]
		metallica	MIDV[1, 5], WNV[1, 19], BBKV[5]
Culex	*Culex*	*antennatus*	PGAV[1], WNV[1, 5, 19], RVFV[2, 20], SINV[1], WSLV[5], BBKV[5], NRIV[5]
		decens group	WNV[5, 19], CHIKV[5], BBKV[5]
		neavei	SPOV[1, 4], WNV[5, 8, 12, 19], SINV[8], BBKV[5] KOUV[5]
		perfuscus	ORUV[1, 5], USUV[1, 5], WNV[1, 5, 19], WSLV[1, 5], SINV[5], BBKV[5]
		pipiens	JBEV[1], LACV[1], SFV[1], SLEV[1], TAHV[1], WEEV[1], WNV[19], BANV [5], BUNV[5]
		pruina	SINV[1, 5], WNV[1, 5, 19]
		quinquefasciatus	CHIKV[1, 5], EEEV[1], KUNV[1], MTBV[1], MURV[1], OROV[1], RRV[1], SLEV[1], SINV[1], VEEV[1], WANV[1], WEEV[1], WNV[1, 5, 19], BBKV[5]
		univittatus	SINV[1, 25], SPOV[1], USUV[1, 5], WSLV[1], WNV[1, 5, 19]
		zombaensis	BUNV[1, 5], PGAV[1], RVFV[2]
	Culiciomyia	*cinereus*	CHIKV[5], MIDV[5], BBKV[5]
		nebulosus	MIDV[5], BBKV[5], BGIV[5]
	Eumelanomyia	*rubinotus*	BANV[1], GERV[1, 5], RVFV[2]
	Lutzia	*tigripes*	SINV[1, 5], BBKV[5]
	Oculeomyia	*annulioris*	MIDV[5], WSLV[5]

Genus	Subgenus	Species	Arbovirus(es)
	Oculeomyia	*poicilipes*	RVFV[5, 11], WNV[5, 12, 19], MIDV[5], PGAV[5], BBKV[5], NRIV[5]
Eretmapodites		*chrysogaster*	MIDV[1, 5], RVFV[1, 2], SFV[5]
Mansonia	*Mansonioides*	*africana*	BANV[1], BUNV[1, 5, 12], CHIKV[1, 5], LEBV[1], MIDV[1, 5], PGAV[1, 5], SHOV[1], SPOV[1, 4], USUV[1, 5], WSLV[1, 5], RVFV[5, 20], WNV[5], BBKV[5]
		uniformis	BUNV[1, 5, 12], MIDV[1, 5], RRV[1], SPOV[1, 4], WSLV[1, 5], ZIKAV[1, 5], WNV[5, 11], CHIKV[5], BANV[5], RVFV[5]
Mimomyia	*Mimomyia*	*hispida*	WNV[5, 12, 19], BBKV[5]
		plumosa	PGAV[5]
Uranotaenia	*Pseudoficalbia*	*mashonaensis*	WSLV[5]

[1] The International Catalogue of Arboviruses.

[2] Meegan & Bailey 1988.

[3] McIntosh *et al.* 1972.

[4] ARBOCAT (http://wwwn.cdc.gov/arbocat/index.asp).

[5] Institut Pastuer de Dakar. Rapport Annuel, 2000.

[6] Monath 1988.

[7] McCrae & Kirya 1982.

[8] McIntosh 1986.

[9] Lutwama *et al.* 1999.

[10] Woodhall 1964.

[11] Diallo *et al.* 2005.

[12] Traore-Lamizana 2001.

[13] Mahaffy *et al.* 1942.

[14] Smithburn & Haddow 1946.

[15] Williams *et al.* 1965.

[16] Corbet *et al.* 1961.

[17] Smithburn *et al.* 1948

[18] MacIntosh *et al.* 1961.

[19] Hubálek & Halouzka 1999.

[20] Fontenille *et al.* 1998.

[21] Germain *et al.* 1980.

[22] Diallo *et al.* 2003.

[23] Marchette *et al.* 1969.

[24] Lee & Moore 1972.

[25] Jupp *et al.* 1986.

BANV = Banzi virus. BBKV = Babanki virus. BGIV = Bangui virus. BUNV = Bunyamwera virus. BWAV = Bwamba virus. CHIKV = Chikungunya virus. DENV-1 = Dengue type 1 virus. DENV-2 = Dengue type 2 virus. DEN-3 = Dengue type 3 virus. DEN4 = Dengue type 4 virus. DUGV = Dugbe virus. EEEV = Eastern Equine Encephalitis virus. GERV = Germiston virus. ILEV = Ilesha virus. JBEV = Japaneese Encephalitis virus. KOUV = Koutango virus. KUNV = Kunjin virus. LACV = LaCrosse Encephalitis virus. LEBV = Lebombo virus. MIDV = Middelburg virus. MTBV = Marituba virus. MURV = Murray Valley virus. NDOV = Nyando virus. NRIV = Ngari virus. ONNV = Onyong-Nyong virus. OROV = Oropouche virus. ORUV = Orungo virus. PGAV = Pongola virus. RRV = Ross River virus. RVFV = Rift Valley Fever virus. SFV = Semliki Forest virus. SHOV = Shokwe virus. SINV = Sindbis virus. SLEV = St. Louis Encephalitis virus. SPOV = Spondweni virus. TAHV = Tahyna virus. TATV = Tataguine virus. USUV = Usutu virus. VEEV = Venezuelan Equine Encephalitis virus. WANV = Wanowrie virus. WEEV = Western Equine Encephalitis virus. WSLV = Wesselsbron virus. WNV = West Nile virus. YFV = Yellow Fever virus. ZIKAV = Zika virus.