HHS Public Access

Author manuscript

J Entomol Zool Stud. Author manuscript; available in PMC 2015 September 04.

Published in final edited form as:

J Entomol Zool Stud. 2014 November ; 2(5): 317–322.

STUDIES ON THE SPECIES COMPOSITION AND RELATIVE ABUNDANCE OF MOSQUITOES OF MPIGI DISTRICT, CENTRAL UGANDA

Martin Mayanja[1], **John-Paul Mutebi**[2], **Mary B. Crabtree**[2], **Fred Ssenfuka**[1], **Teddy Muwawu**[1], and **Julius J. Lutwama**[1]

[1]Department of Arbovirology, Uganda Virus Research Institute, P.O. BOX 49, Entebbe, Uganda
[2]Centers for Disease Control and Prevention, Division of Vector-Borne Diseases,3156 Rampart Road, Fort Collins, CO 80521, USA

Abstract

Prediction of arboviral disease outbreaks and planning for appropriate control interventions require knowledge of the mosquito vectors involved. Although mosquito surveys have been conducted in different regions of Uganda since the mid 30's such studies have not been carried out in Mpigi District. In October 2011, we conducted mosquito collections in Mpigi district to determine species composition and relative abundance of the different species. The survey was conducted in four villages, Njeru, Ddela, Kiwumu and Nsumbain Kammengo sub-county, Mpigi district, Uganda. CDC light traps baited with dry ice (carbon dioxide) were used to capture adult mosquitoes. A total of 54,878 mosquitoes comprising 46 species from eight genera were collected. The dominant species at all sites was *Coquilletidia (Coquilletidia) fuscopennata* Theobald (n=38,059, 69%), followed by *Coquillettidia (Coquillettidia) metallica* Theobald (n=4,265, 7.8%). The number of species collected varied from 17 in the genus *Culex* to 1 in the genus *Lutzia*. Of the 46 species identified, arboviruses had previously been isolated from 28 (60.9%) suggesting a high potential for arboviral transmission and/or maintenance in Mpigi District.

Keywords

mosquito; Mpigi; species composition; Uganda

Introduction

Mosquitoes of Uganda were extensively investigated between the mid-1930s and the early 1970s [1]. During that period more than 220 mosquito species were recorded and approximately 20% were implicated in arbovirus transmission [2]. Because of these investigations, Uganda is currently a known hotspot for emergence of arboviruses of public health and veterinary importance [3, 4]. Although earlier studies have described species composition, distribution, behavior and preferred habitat of mosquitoes in Uganda, most of these studies were conducted >40 years ago and only in limited areas of the country [1, 5–17]. Such information has been more recently updated by Mutebi *et al* [1] for western Uganda and Kaddumukasa *et al*. [18] for Zika Forest. In the intervening years arthropod surveillance

activities in Uganda have mainly been limited to collections related to specific taxonomic questions or to monitoring vectors during outbreaks, such as the O'nyong-nyong virus(ONNV) outbreak in 1996 [19, 20]. Therefore, more generalized mosquito surveys are needed to develop distribution maps of medically significant vector species to facilitate prediction and planning for appropriate control strategies for arboviral outbreaks.

We report here a description of mosquitoes of Mpigi district in central Uganda, an area for which mosquito species composition and abundance data is not available. This study was part of the arbovirus surveillance program recently established at the Uganda Virus Research Institute (UVRI) in Entebbe, Uganda, in collaboration with the US Centers for Disease Control and Prevention. This study is a first step toward surveillance for arboviruses of public health and veterinary importance in Mpigi District.

Materials and Methods

Collection sites

Mosquito collections were conducted in Kammengo Sub County, Mpigi District in central Uganda (Fig. 1). This district is approximately 37 km west of Kampala and borders Wakiso District to the North and East, Kalungu District to the South, Butambala District to the West and Mityana District to the North-West. Mosquitoes were collected from four villages: Njeru (Lat 0.113533, Lon 32.22035), Ddela (Lat 0.106433, Lon 32.2248), Kiwumu (Lat 0.086867, Lon 32.234183) and Nsumba (Lat 0.083467, Lon 32.206917) (Fig. 1). The distance between the collection sites ranged from 0.9 km (Njeru to Ddela) to 3.6 km (Njeru to Nsumba) with a median distance of 3.1 km. The altitude at the study site was between 1166m and 1194m above sea level. The collection sites were in plantations and small gardens close to residential areas and near wetlands that stretch to the shores of Lake Victoria. The primary occupation of the local population in the area is subsistence farming; mostly small scale banana and coffee plantations, vegetable fields and/or gardens and limited rearing of cattle, goats, ducks, chickens and other farm animals.

Mosquito collection

Mosquito collections were made from October 15 through 24, 2011. CDC light traps baited with dry ice (carbon dioxide) were suspended on tree branches in coffee plantations, banana plantations and bushes near homes. Twenty five CDC light traps were hung at each site at approximately 5:00pm, left overnight for about 14 hours and collected each morning at approximately 8:00am. Collections were made at each site for 2 nights. The contents of the traps were sorted into cryovials and transported frozen in liquid nitrogen dry shippers to the UVRI laboratory in Entebbe where they were stored at −80°C until identification.

Mosquitoes were identified to species using the morphological keys of Edwards [21], Huang [22], Jupp [23], Gilles and De Mellion [24], and Gilles and Coetzee[25]. Specimens were pooled by species, sex, feeding status and parity and stored at −80°C for virus isolation studies. Voucher specimens were retained for each species for future reference and identification consultation.

Diversity Indices

Species richness and diversity were calculated for each collection location. While species richness is the number of mosquito species at each location, species diversity takes into account both species richness and the relative abundance of each species. Species diversity was estimated by using the Simpson Index[26]. The Simpson Index was calculated as $D=\sum n(n-1)/N(N-1)$ where n= the total number of mosquitoes of a particular species and N=the total number of mosquitoes of all species in each collection. We also report the Simpson's Index of Diversity (1-D), which is interpreted as the greater the index value, the greater the sample diversity.

Results and Discussion

A total of 54,878 mosquitoes belonging to 9 genera and 45 species were identified. The number of mosquitoes collected from the individual sites was: Njeru (n=16,403), Ddela (n=16,818), from Kiwumu (n=12,099) and Nsumba (n=9,555). Table 1 lists the species captured by collection site. Twenty (44.4%) of the 45 species were captured at all four collection sites which suggests differences in species composition between the sites despite their close proximity (Table 1). Recently Mutebi *et al*. [1] reported differences in species composition between the adjacent sites of Mweya and Maramagambo in western Uganda which suggested that the geographic distance between sites may not be a major determining factor. However, it is important to note that Maramagambo is a forest ecosystem whereas Mweya is an open grassland and therefore the differences in species composition between these two sites may be attributed to differences between the ecosystems. In the present study, 98.5% of the collection belonged to species found at all four sites; the majority of the species that were not captured at all four sites were captured in low numbers. This was most likely due to low abundance or because the species were not strongly attracted to CO_2-baited light traps. Species diversity for the four collection sites, estimated by using the Simpson Index/Index of Diversity which takes into consideration the relative abundance of mosquitoes in each species, ranged from 0.42 – 0.53 (Table 1)[26]. These values suggest that overall the four collection sites supported similar species diversity.

Figure 2 summarizes the species richness or number of species in each genus collected at the four sites. The highest number of species was in the genus *Culex* at all four sites (Figure 2). At three sites, Ddela, Kiwumu and Nsumba, the second highest number of species was in the genus *Coquillettidia* and the third in the genus *Aedes* (Figure 2). At Njeru, the second highest number of species was in the genus *Aedes*, and the third in genus *Coquillettidia* (Table 2). Overall species richness by genus ranged from 37.0% in the genus *Culex* (37% of all species collected were in the genus *Culex*) to 2.2% in *Hodgesia* and *Mimomyia* (Fig. 2). The genus *Culex* was highest in species richness comprising 17 species (n=5,548, 10.1% of the total collection), followed by the genus *Aedes* (n=611, 1.1%) with 9 species (19.6%) (Table 1, Fig 2). Although the genus *Coquillettidia* had the highest number of mosquitoes captured (n=47,697, 86.9%), it ranked third in terms of species richness with 8 species (17.4%) (Table 1, Fig 2). The *Uranotaenia* and *Mansonia* genera had identical species richness with 6.5% each of the total species identified (Fig 2). The rest of the species were in

the genera *Anopheles*, *Hodgesia* and *Mimomyia* and had minimal contribution to the total species richness in the area (Fig 2).

The most abundant mosquitoes were in the genus *Coquillettidia* followed by the genus *Culex* (Table 1). The predominant species collected was *Coquillettidia* (*Coquillettidia*) *fuscopennata* (Theobald) (n=38,059, 69.4%), followed by *Coquillettidia* (*Coquillettidia*) *metallica* (Theobald) (n=4,265, 7.8%) and *Coquillettidia* (*Coquillettidia*) *fraseri* (Theobald) (n=3,129, 5.7%) (Table 1). *Coquillettidia* species are often the principal species collected near water/wetlands which are their preferred larval habitats. The ecology of the study area in Mpigi District included freshwater swampland in addition to small scale agricultural landscapes adjacent to human habitation, therefore, the large numbers of *Coquillettidia* mosquitoes collected was not unexpected. The next most abundant species collected were *Culex* (*Oculeomyia*) *annulioris* Theobald (n=2,883, 5.3%) and *Culex* (*Culex*) *decens* group Theobald and *Culex* (*Culex*) *invidiosus* Theobald)(n=1,187, 2.2%) (Table 1)[21]. Additional species contributing >0.5% to the collection included *Coquillettidia* (*Coquillettidia*) *maculipennis* (Theobald) (n=611, 1.1%), *Coquillettidia* (*Coquillettidia*) *aurites* (Theobald) (n=603, 1.1%), *Coquillettidia* (*Coquillettidia*) *cristata* (Theobald) (n=480, 0.9%), *Culex* (*Culiciomyia*) *cinereus* (Theobald)(n=462, 0.8%), *Aedes* (*Neomelaniconion*) *circumluteolus* (Theobald) (n=401, 0.7%), *Mansonia* (*Mansonioides*) *africana nigerrima* Theobald (n=399, 0.7%) and *Coquillettidia* (*Coquillettidia*) *pseudoconopas* (Theobald) (n=296, 0.5%) (Table 1).

Of the 46 mosquito species collected in this study arboviruses of medical and veterinary importance had previously been isolated from 28 (60.9%) suggesting roles in the transmission or the maintenance of these arboviruses. This shows a high potential for maintenance and transmission of arboviruses of medical and veterinary importance in Mpigi District. A comprehensive list of arboviruses that have been isolated from mosquito species collected in Uganda has been published by Mutebi *et al*. [1]. For many of these species it is unknown whether they play a significant role in epidemic or enzootic virus transmission. However, certain species in the collection are known to be epidemic/enzootic vector species including *Aedes* (*Stegomyia*) *aegypti* (L.), a principal vector of Yellow fever virus (YFV) [27, 28], Chikungunya virus [29], Dengue viruses[30] and Zika virus [31]. Similarly, members of the *Aedes* (*Stegomyia*) *simpsoni* group have been shown to be epidemic vectors of YFV [32, 33] and members of the *Anopheles* (*Cellia*) *gambiae* group are vectors of ONNV[20, 34]. Additionally epidemic and epizootic transmission of Rift Valley fever virus has been implicated for several species collected in Mpigi district including *Aedes* (*Neomelaniconion*) *mcintoshi/circumluteolus*, *Mansonia* (*Mansonioides*) *africana* (Theobald), *Mansonia* (*Mansonioides*) *uniformis* (Theobald), *Culex* (*Culex*) *pipiens* (L.), *Culex* (*Culex*) *quinquefasciatus* Say, *Culex* (*Oculeomyia*) *annulioris* Theobald and *Culex* (*Oculeomyia*) *poicilipes* Theobald[35–40]. Some known disease vectors identified in this collection were not captured at all four sites suggesting non-uniform distribution of these vectors in the study sites and an uneven risk of disease transmission across the region. For example members of the *Anopheles* (*Cellia*) *gambiae* group were only detected at Ddela and not at any other study site (Table 1). Similarly, *Culex* (*Culex*) *pipiens* (L) was only detected at Ddela (Table 1). Interestingly *Culex* (*Culex*) *quinquefasciatus* Say, which is closely

related to *Cx. pipiens*, was only detected at Nsumba and not at any other study site (Table 1). Both *Cx. pipiens* and *Cx. quinquefasciatus* which are commonly captured in C02-baited light traps were found in low numbers suggesting that the densities of these two species were low at the study sites. *Cx. pipiens* and *Cx. quinquefasciatus* are commonly associated with human residences (domestic species). Since collections in this study were conducted in domestic and peridomestic areas, our observations suggest that the risk of *Cx. pipiens* and *Cx. quinquefasciatus*-transmitted pathogens is low in this area.

To our knowledge this is the first documented account of the mosquito fauna of Mpigi District in central Uganda. All of the 45 species identified had previously been identified elsewhere in Uganda and do not represent new introductions to the country. Species richness in this area was high and >60% of the mosquito species collected have been previously documented as potential arbovirus vectors. Increased human activity and encroachment in to undeveloped areas in this region presents a potential risk for exposing humans to arboviral diseases. Historical records show that Uganda has experienced numerous outbreaks of arboviral disease including YFV and ONNV[20, 41] and many known arboviruses were first isolated from Uganda[3, 4]. Further study is necessary to determine the seasonal variation in mosquito species composition and abundance in this region. Additionally, virus isolation from collected mosquitoes will be conducted to identify arboviruses that are currently circulating in the area. Such information will be invaluable in predicting and controlling potential outbreaks of arboviral disease in this region.

Acknowledgments

We would like to thank the Chairman and the local health officials of Kammengo Sub County for granting us permission to conduct these studies. We especially thank the residents of Njeru, Ddela, Kiwumu and Nsumba villages for giving us free access to their properties. We also thank John-Bosco Lwanga, Julius Mugga and Godfrey Kyazze for their assistance during the mosquito collection in the field. This study was supported with funds from the US Centers for Disease Control and Prevention (CDC) and USAID Emerging Pandemic Threat Program.

References

1. Mutebi JP, Crabtree MB, Kading RC, Powers AM, Lutwama JJ, Miller BR. Mosquitoes of western Uganda. J Med Entomol. 2012; 49:1289–306. [PubMed: 23270157]
2. Lutwama JJ. Uganda Arbovirus Surveillance Activities. African J Pharmacol Therapeut. 2012
3. Sempala SDK. Institute profile: The Uganda Virus Research Institute. Trends Microbiol. 2002; 10:346–348. [PubMed: 12110215]
4. Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, et al. Global trends in emerging infectious diseases. Nature. 2008; 451:990–993. [PubMed: 18288193]
5. Dick GWA, Haddow AJ. Uganda S virus a hiterto unrecorded virus isolated from mosquitoes in Uganda. Trans R Soc Trop Med Hyg. 1952; 46:600–618. [PubMed: 13005679]
6. Haddow AJ. On the mosquitoes of Bwamba County, Uganda. I. Description of Bwamba with special reference to mosquito ecology. Proceedings of the Zoological Society of London. 1945; 115:1–13.
7. Haddow AJ. The mosquitoes of Bwamba County, Uganda. II. Biting activity with special reference to the influence of microclimate. Bull Entomol Res. 1945; 37:57–82.
8. Haddow AJ. The mosquitoes of Bwamba County, Uganda. IV. Studies on the genus *Eretmapodites*. Theobald Bull Entomol Res. 1946; 37:57–82.

9. Haddow AJ, Gillett JD, Highton RB. 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. 1947; 37:301–330. [PubMed: 20284933]
10. Haddow AJ, Smithburn KC, Dick GWA, Kitchen SF, Lumsden WHR. Implication of the mosquito *Aedes (Stegomyia) africanus* Theobald in the forest cycle of yellow fever virus in Uganda. Ann Trop Med Parasitol. 1948; 42:218–223. [PubMed: 18891448]
11. Haddow AJ, van Someren ECC, Lumsden WHR, Harper JO, Gillett JD. The mosquitoes of Bwamba County, Uganda. VIII. Records of occurrence, behavior and habitat. Bull Entomol Res. 1951; 42:207–238.
12. Haddow AJ, Mahaffy AF. The mosquitoes of Bwamba County, Uganda. VII. Intensive catching on tree platforms, with further observations on *Aedes (Stegomyia) africanus* Theobald. Bull Entomol Res. 1949; 40:169–178. [PubMed: 18139173]
13. Haddow AJ, van Someren ECC. A new species of *Stegomyia* Theobald from the Ruwenzori range, Uganda. Ann Trop Med Parasitol. 1950; 44:281–284. [PubMed: 24538830]
14. Smithburn KC, Haddow AJ. Semliki forest virus. I. Isolation and pathogenic properties. J Immunol. 1944; 49:141–157.
15. Smithburn KC, Haddow AJ. Isolation of yellow fever from African mosquitoes. Am J Trop Med Hyg. 1946; 26:261–271. [PubMed: 20988053]
16. Smithburn KC, Haddow AJ. Ntaya virus: a hitherto unknown agent isolated from mosquitoes collected in Uganda. Proc Soc Exp Biol Med. 1951; 77:130–133. [PubMed: 14844417]
17. Smithburn KC, Mahaffy AF, Paul JH. Bwamba fever and its causative virus. Am J Trop Med Hyg. 1941; 21:75–90.
18. Kaddumukasa MA, Mutebi JP, Lutwama JJ, Masembe C, Akol AM. Mosquitoes of Zika Forest, Uganda: species composition and relative abundance. J Med Entomol. 2014; 51:104–13. [PubMed: 24605459]
19. Lutwama JJ, Mukwaya LG. Variation in morphological characters of adults of *Aedes (Stegomyia) simpsoni* complex from Uganda, Kenya and South Africa (Diptera:Culicidae). Mosq Syst. 1994; 26:145–157.
20. Lutwama JJ, Kayondo J, Savage HM, Burkot TR, Miller BR. Epidemic o'nyong-nyong fever in southcentral Uganda, 1996–1997: Entomologic studies in Bbaale village, Rakai district. Am J Trop Med Hyg. 1999; 61:158–162. [PubMed: 10432073]
21. Edwards, FW. Culcine adults and pupae. London: London British Museum of Natural History; 1941. Mosquitoes of the Ethiopian Region III.
22. Huang YM. The subgenus Stegomyia of Aedes in the afrotropical region with keys to the species (Diptera: Culicidae). Zootaxa. 2004; 700:1–120.
23. Jupp, PG. Mosquitoes of Southern Africa. South Africa: Ekogilde; 1996. p. 156
24. Gillies, MT.; DeMeillon, B. Ethiopian Zoogeographical region. Johannesburg: South African Institute for Medical Research; 1968. The Anophelinae of Africa South of the Sahara.
25. Gillies, MT.; Coetzee, M. A Supplement to the Anophelinae of Africa South of the Sahara (Afrotropical Region). Johannesburg: The South African Institute for Medical Research; 1987.
26. Simpson EH. Measurement of diversity. Nature. 1949; 163:688.
27. Monath, TP. Yellow Fever. In: Monath, TP., editor. The Arboviruses: Epidemiology and Ecology. American Public Health Association; Washington, D.C: 1988.
28. Germain M, Francy DB, Monath TP, Ferrara L, Bryan J, Salaun JJ, et al. Yellow-Fever in the Gambia, 1978–1979 - Entomological Aspects and Epidemiological Correlations. Am J Trop Med Hyg. 1980; 29:929–940. [PubMed: 7435794]
29. Jupp, PG.; McIntosh, BM. Chikungunya, a virus disease. In: Monath, TP., editor. The Arboviruses: Epidemiology and Ecology. American Public Health Association; Washington, D.C: 1988.
30. Gubler, DJ. Dengue. In: Monath, TP., editor. The Arboviruses: Epidemiology and Ecology. American Public Health Association; Washington, D.C: 1988.
31. Marchette NJ, Garcia R, Rudnick A. Isolation of Zika virus from *Aedes aegypti* mosquitoes in Malaysia. Am J Trop Med Hyg. 1969; 18:411–415. [PubMed: 4976739]
32. Mahaffy AF. Yellow fever in western Uganda. Trans R Soc Trop Med Hyg. 1942; 36:9–20.

33. Huang YM. *Aedes (Stegomyia) Bromeliae* (Diptera, Culicidae), the Yellow-Fever Virus Vector in East-Africa. J Med Entomol. 1986; 23:196–200. [PubMed: 3701804]

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

35. Sang R, Kioko E, Lutomiah J, Warigia M, Ochieng C, O'Guinn M, et al. Rift Valley fever virus epidemic in Kenya, 2006/2007: the entomologic investigations. Am J Trop Med Hyg. 2010; 83:28–37. [PubMed: 20682903]

36. Morvan J, Rollin PE, Laventure S, Rakotoarivony I, Roux J. Rift Valley fever epizootic in the central highlands of Madagascar. Res Virol. 1992; 143:407–15. [PubMed: 1297176]

37. Meegan JM, Hoogstraal H, Moussa MI. An epizootic of Rift Valley fever in Egypt in 1977. Vet Rec. 1979; 105:124–5. [PubMed: 505918]

38. Digoutte JP, Jacobi JC, Robin Y, Gagnard VJ. Zinga virus infection in man. Bull Soc Pathol Exot Filiales (Paris). 1974; 67:451–457.

39. Digoutte JP, Cordellier R, Robin Y, Pajot FX, Geoffrey B. Zinga virus (Ar B 1976), a new arbovirus isolated in central Africa. Ann Microbiol (Paris). 1974; 125B:107–118. [PubMed: 4157115]

40. Linthicum KJ, Davies FG, Kairo A, Bailey CL. Rift Valley fever virus (family Bunyaviridae, genus Phlebovirus). Isolations from Diptera collected during an inter-epizootic period in Kenya. J Hyg (Lond). 1985; 95:197–209. [PubMed: 2862206]

41. Wamala JF, Malimbo M, Okot CL, Atai-Omoruto AD, Tenywa E, Miller JR, et al. Epidemiological and laboratory characterization of a yellow fever outbreak in northern Uganda, October 2010–January 2011. Int J Infect Dis. 2012; 16:E536–E542. [PubMed: 22575876]

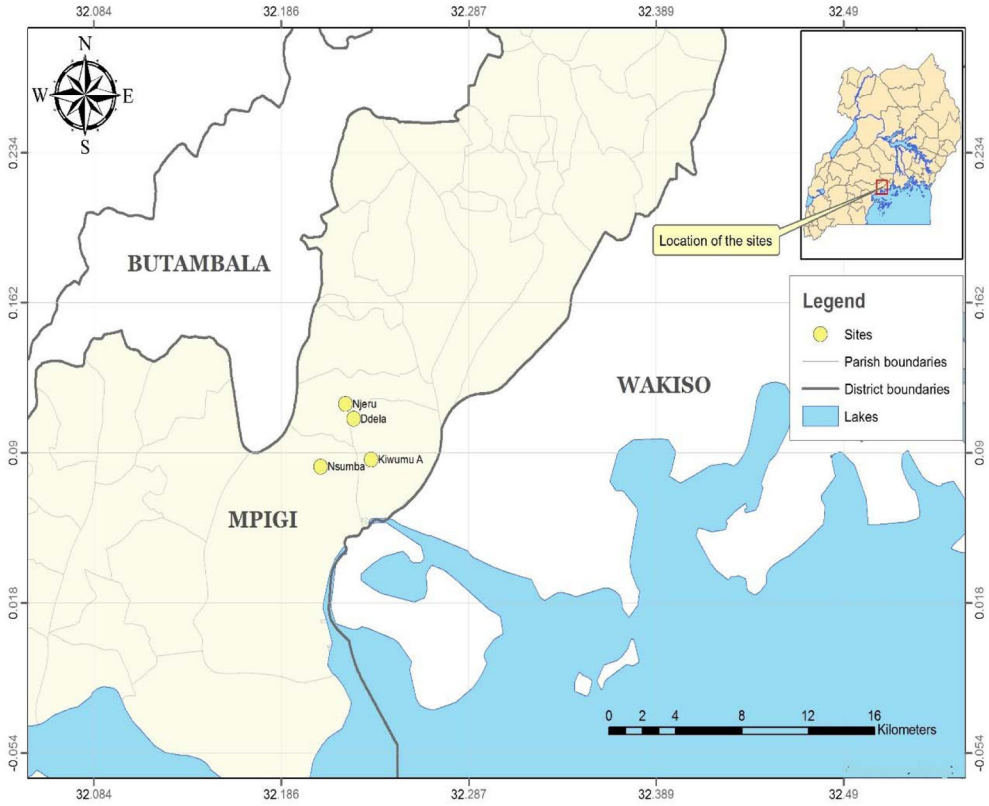

Fig. 1.
Location of collection sites in Mpigi District, Uganda.

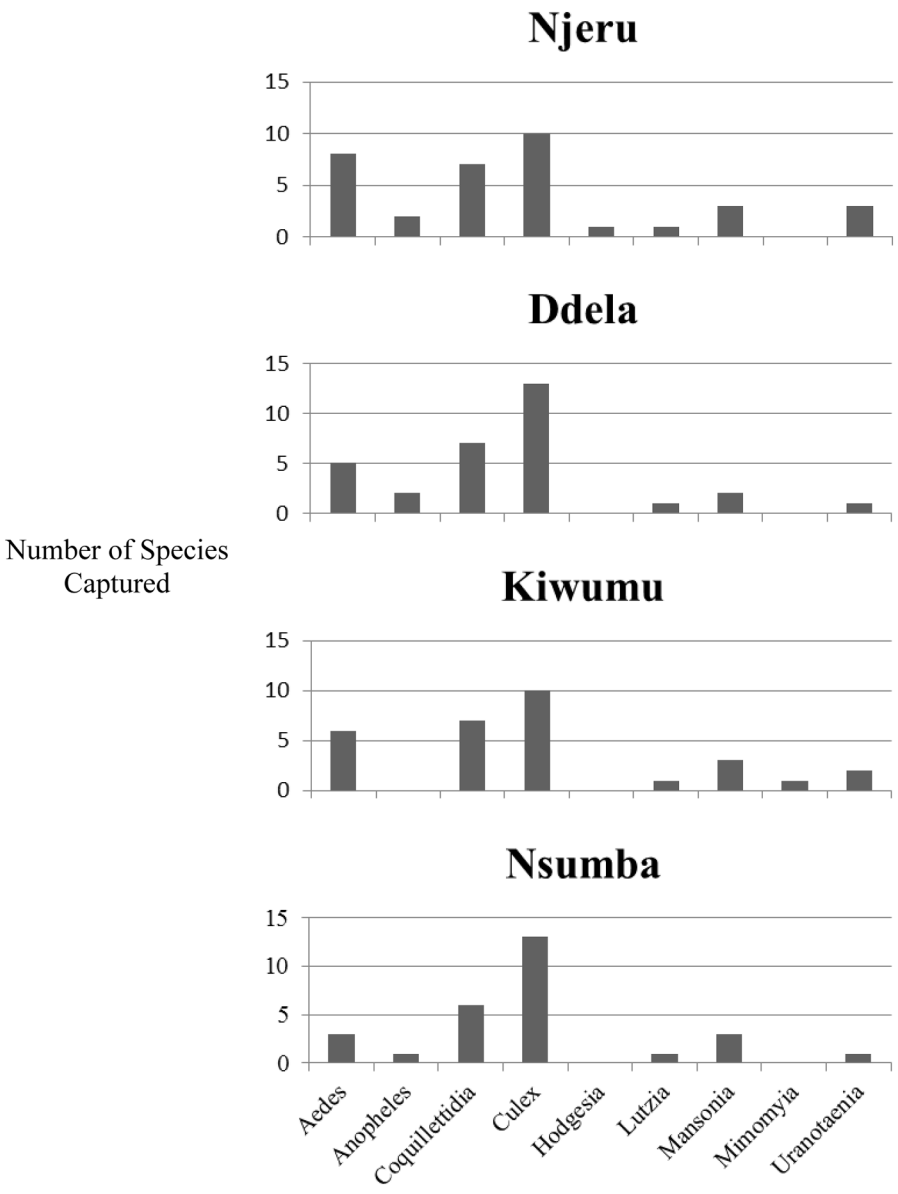

Figure 2.
Number of mosquito species collected in each genus by study site.

Table 1

Mosquito species collected in Mpigi District, central Uganda, in October 2011.

Genus	Subgenus	Species	Number collected (%)									
			Njeru		Ddela		Kiwumu		Nsumba		All sites	
Aedes	*Aedimorphus*	*argenteopunctatus* (Theobald)	3	(0.02)							3	(0.01)
		cumminsii (Theobald)	26	(0.16)							26	(0.05)
		phyllolabis Edwards	25	(0.16)	10	(0.06)	10	(0.08)	10	(0.10)	55	(0.10)
		tarsalis (Newstead)					3	(0.02)			3	(0.01)
	Finlaya	*ingrami Edwards*	1	(0.01)	1	(0.01)					2	(0.00)
	Neomelaniconion	*circumluteolus* (Theobald)	136	(0.85)	112	(0.67)	113	(0.93)	40	(0.42)	401	(0.73)
		mcintoshi Huang	19	(0.12)	25	(0.15)	25	(0.21)	22	(0.23)	91	(0.17)
	Stegomyia	*aegypti* (L.)	1	(0.01)	6	(0.04)	8	(0.07)			15	(0.03)
		simpsoni group[a]	1	(0.01)			2	(0.02)			3	(0.01)
		species			4	(0.02)	8	(0.07)			12	(0.02)
Anopheles	*Anopheles*	*coustani* Laveran	5	(0.03)	7	(0.04)			1	(0.01)	13	(0.02)
		implexus (Theobald)	10	(0.06)							10	(0.02)
	Cellia	*gambiae* group[b]			26	(0.15)					26	(0.05)
Coquillettidia	*Coquillettidia*	*aurites* (Theobald)	186	(1.16)	187	(1.11)	155	(1.28)	75	(0.78)	603	(1.10)
		fraseri (Theobald)	774	(4.82)	1292	(7.68)	476	(3.93)	587	(6.14)	3129	(5.70)
		fuscopennata (Theobald)	11508	(71.73)	11412	(67.86)	9175	(75.83)	6444	(67.44)	38539	(70.23)
		maculipennis (Theobald)	238	(1.48)	135	(0.80)	148	(1.22)	90	(0.94)	611	(1.11)
		metallica (Theobald)	1142	(7.12)	1754	(10.43)	689	(5.69)	674	(7.05)	4259	(7.76)
		pseudoconopas (Theobald)	52	(0.32)	134	(0.80)	57	(0.47)	53	(0.55)	296	(0.54)
		versicolor (Barraud)	49	(0.31)	124	(0.74)	56	(0.46)			229	(0.42)
		species	15	(0.09)			16	(0.13)			31	(0.06)
Culex	*Culex*	*antennatus* (Becker)	52	(0.32)	29	(0.17)	19	(0.16)	41	(0.43)	141	(0.26)
		decens group[c]	176	(1.10)	373	(2.22)	261	(2.16)	377	(3.95)	1187	(2.16)
		neavei Edwards			9	(0.05)	7	(0.06)	80	(0.84)	96	(0.17)
		ornatothoracis Theobald	56	(0.35)	44	(0.26)	42	(0.35)	45	(0.47)	187	(0.34)
		perfuscus Edwards							11	(0.12)	11	(0.02)

Genus	Subgenus	Species	Number collected (%)									
			Njeru		Ddela		Kiwumu		Nsumba		All sites	
		pipiens (L.)			2	(0.01)					2	(0.00)
		quinquefasciatus Say							2	(0.02)	2	(0.00)
		trifilatus Edwards			1	(0.01)			19	(0.20)	20	(0.04)
	Culiciomyia	*cinerellus* Edwards			1	(0.01)					1	(0.00)
	Culiciomyia	*cinereus* Theobald	257	(1.60)	117	(0.70)	21	(0.17)	67	(0.70)	462	(0.84)
		nebulosus Theobald	23	(0.14)	13	(0.08)			116	(1.21)	152	(0.28)
	Eumelanomyia	*insignis* (Carter)	22	(0.14)	37	(0.22)	24	(0.20)	30	(0.31)	113	(0.21)
		rubinotus Theobald	50	(0.31)	29	(0.17)	103	(0.85)	66	(0.69)	248	(0.45)
	Kitzmelleria	*moucheti* Evans			5	(0.03)	1	(0.01)	4	(0.04)	10	(0.02)
	Oculeomyia	*annulioris* Theobald	1212	(7.55)	746	(4.44)	439	(3.63)	486	(5.09)	2883	(5.25)
		annulioris consimilis Newstead	13	(0.08)			20	(0.17)			33	(0.06)
		poicilipes Theobald	3	(0.02)							3	(0.01)
		species							14	(0.15)	14	(0.03)
Hodgesia	*Hodgesia*	*sanguinae* Theobald	17	(0.11)							17	(0.03)
		species	32	(0.20)							32	(0.06)
Lutzia	*Metalutzia*	*tigripes* de Grandpre & de Charmoy	26	(0.16)	36	(0.21)	18	(0.15)	28	(0.29)	108	(0.20)
Mansonia	*Mansonioides*	*africana* (Theobald)	4	(0.02)			10	(0.08)	2	(0.02)	16	(0.03)
		africana nigerrima Theobald	178	(1.11)	90	(0.54)	68	(0.56)	63	(0.66)	399	(0.73)
		uniformis (Theobald)	65	(0.41)	32	(0.19)	32	(0.26)	36	(0.38)	165	(0.30)
Mimomyia	*Mimomyia*	*hispida* (Theobald)					2	(0.02)			2	(0.00)
Uranotaenia	*Pseudoficalbia*	*mashonaensis* Theobald	2	(0.01)			2	(0.02)			4	(0.01)
	Uranotaenia	*alboabdominalis* Theobald	3	(0.02)							3	(0.01)
		palidocephala Theobald	21	(0.13)	25	(0.15)	63	(0.52)	47	(0.49)	156	(0.28)
		species					26	(0.21)	25	(0.26)	51	(0.09)
Total			16403		16818		12099		9555		54875	
Grand total		54,875										
D			0.51		0.48		0.58		0.47		0.51	
1-D			0.49		0.52		0.42		0.53		0.49	

[a]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, and *Ae. woodi* Edwards[22].

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

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