

Rapid assessment of the geographical distribution of *Mansonella perstans* infections in Uganda, by screening schoolchildren for microfilariae

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The geographical distribution of *Mansonella perstans* infections in Uganda was assessed by day-time examination of school-aged children for microfilariae. Overall, 12,207 children from 76 sites representing the various topographical and ecological zones in the country were examined. Children with *M. perstans* microfilaraemia were detected at 47 (61.8%) of the study sites, with prevalences ranging from 0.4% to 72.8%. A broad, east–west-oriented belt of high endemicity was identified, stretching across the central part of the country from the southern end of Lake Albert to the north–western shores of Lake Victoria. To the north and south of this belt prevalences generally decreased, although high-prevalence foci were also identified in the far north–western and south–eastern corners of the country. Geostatistical interpolation was used to create a map showing the geographical distribution of *M. perstans* prevalences in Uganda (by ordinary kriging), and to assess the population exposed to *M. perstans* transmission. Estimates based on population data from 2002 indicated that 20.4 million people (82.6% of the national population) and 6.8 million people (27.5% of the national population) lived in areas where, respectively, >1% and >10% of the school-aged children had *M. perstans* microfilaraemias. Since the prevalence of *M. perstans* microfilaraemia is known to increase with age, the overall population prevalences are likely to be even higher than the prevalences observed in the school-aged children. More attention needs to be paid to the public-health implications of this wide-spread but neglected infection.

Given that *Mansonella perstans* is a wide-spread parasite of humans in many parts of Africa, surprisingly little is known of its epidemiology and geographical distribution. The adult filariae live primarily in the abdominal cavity, the microfilariae (mff) circulate in the blood, and tiny biting midges of the genus *Culicoides* are the vectors (Simonsen, 2003). The mff of *M. perstans* were first reported from Uganda by Cook (1901), and Low (1903) and Christy (1903) subsequently reported that human infection with this species was common in many areas of Uganda. There was virtually no research on

this infection for the next 50 years and then Strohschneider (1953) reported cases of severe pathology, believed to be caused by *M. perstans*, in a labour force in Jinja, in eastern Uganda. Brown *et al.* (1970) observed *M. perstans* mff during health surveys in primary schools in Uganda, and a review by Hawking (1977) stated that 40%–50% of inpatients at the main referral hospital in Kampala had *M. perstans* mff in their blood. More recently, attention has been drawn to this infection in Uganda as the result of the activities of the national onchocerciasis-control programme (Tawill *et al.*, 1995; Fischer *et al.*, 1996).

Uganda recently joined the Global Programme to Eliminate Lymphatic

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Filariasis (Ottesen, 2000). Success in this programme requires that the epidemiology and distribution of lymphatic filariasis and other filariases are well known, to facilitate specific targeting, monitoring and evaluation. A few years ago, as a first step, baseline epidemiological investigations were carried out in communities suspected of being endemic for lymphatic filariasis (Onapa *et al.*, 2001a, b). These investigations were subsequently extended, by screening school-aged children for *Wuchereria bancrofti*-specific circulating filarial antigens, to allow the geographical distribution of lymphatic filariasis throughout the country to be mapped (Onapa *et al.*, 2005). At the same time, for the present study, samples of 'day' blood were collected for the preparation of thick smears, so that the prevalence and intensity of day-time microfilaraemias could be determined. As described below, examination of these bloodsmears revealed marked geographical variation in the day-time prevalences of filarial (almost exclusively *M. perstans*) microfilaraemia.

SUBJECTS AND METHODS

Study Design and Study Populations

The study design and the procedures for selection of study sites and study individuals have already been described (Onapa *et al.*, 2005). In brief, children from 72 schools and four communities distributed throughout Uganda and covering all major topographical and ecological zones participated in the study. Prior to each survey, meetings were held with school staff and village leaders, so that the objectives and implications of the study could be explained. Written consent to participate was obtained from those examined (or from the parents of the participants who were aged <15 years). The study received ethical clearance from the Uganda National Council for Science and Technology.

Surveys in primary schools were carried out between October 2000 and April 2003.

Although Uganda has universal primary education, which attracts the majority of children of school-going age, precise information on the percentage of eligible children who were actually attending school in each study area was generally not available. The teachers assisted the survey team in randomly selecting an equal number of boys and girls, in order to reach the target of at least 200 pupils/school. Only children aged 5–19 years were included. Fingerprick samples of blood were collected, during the school day, to be assayed for *W. bancrofti*-specific circulating filarial antigens (Onapa *et al.*, 2005). When possible, and when the child agreed, another (100- μ l) sample was collected from each subject, into a heparinized capillary tube, and used to prepare a rectangular, thick bloodsmear. (As not every subject allowed a second sample to be collected, the number of children checked for microfilaraemia was slightly lower than the number examined for *W. bancrofti* antigens.) The thick smears were allowed to dry before they were dehaemoglobinized, fixed in methanol, stained with Giemsa, and examined under a light microscope. Any mff observed were identified to species, using morphological criteria (WHO, 1987), and counted.

At each study site, a clinical officer from a nearby health unit accompanied the team, examined all the children who were not feeling well and, if necessary, either treated the children or referred them to a nearby clinic.

Data from Onapa *et al.* (2001a, b), on the children aged 5–19 years who were examined in community surveys in 1998, were also included in the analysis (see below).

Mapping and Spatial Analysis

The methods recently used to map the endemicity of *W. bancrofti* in Uganda (Onapa *et al.*, 2005) were applied to the data on *M. perstans*. A global positioning system (Garmin eTrex®; Garmin, Olathe, KS) was

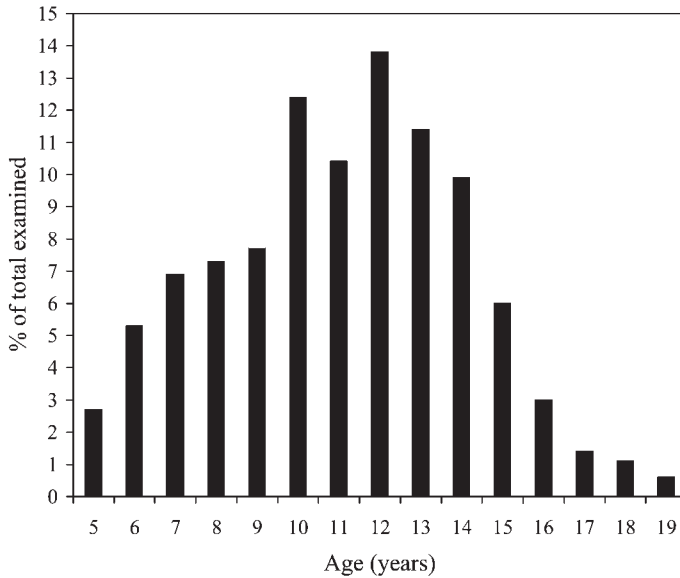


FIG. 1. The age distribution of the 12,207 children examined for *Mansonella perstans* microfilaraemia.

used to determine the longitude and latitude of each site investigated. The corresponding altitudes were then determined from these co-ordinates and the data collected by the Shuttle Radar Topography Mission (SRTM; <ftp://edcsgs9.cr.usgs.gov/pub/data/srtm>); the altitude for each site location was calculated as the mean value of the (approximately 90) cells that lay ≤ 500 m (in horizontal distance) from the site.

Version 8.3 of the ArcGIS® Geostatistical Analyst software package (ESRI, Redlands, CA) was used for spatial analysis, to examine the semivariogram, and to perform geostatistical interpolation (by ordinary kriging) of the microfilaraemia-prevalence data (Burrough and McDonnell, 1998; Johnston *et al.*, 2001). The data were first examined for spatial trends, and a weak parabolic trend was eliminated by second-order trend removal. A spherical model was fitted to the experimental variogram, and range, sill and nugget were slightly adjusted to give the best model fit to the empirical data. The size of the population living within each prevalence zone was derived from the Landscan 2002 digital population model (Oak Ridge National Laboratory, Oak Ridge, TN;

www.ornl.gov/sci/gist/landscan) by performing an overlay of the population model with the prevalence-zone layer.

RESULTS

Study Population

School surveys were conducted in 72 primary schools from 45 districts throughout Uganda [study sites 1–72 in the Table; see also Figure 1 in Onapa *et al.* (2005)]. Overall, 11,727 pupils (5873 boys and 5854 girls) aged 5–19 years were examined, giving a mean of 163 pupils/school. Fewer than 80 pupils were examined in each of four schools (study sites 11, 22, 65 and 66); the survey team experienced an acute shortage of microscope slides at sites 11 and 22, and many pupils at sites 65 and 66 refused to give the requested second blood sample.

Another 480 children aged 5–19 years (210 boys and 270 girls) — who were examined in 1998, during the community surveys of Onapa *et al.* (2001a, b) in Lira, Kaberamaido (formerly part of Soroti district), Katakwi and Kapchorwa districts

TABLE. Overview of study sites, the numbers and ages of the children examined, and the prevalences of *Mansonella perstans* microfilaraemia observed

Study site	District	School name	Altitude (m)	No. and (%) of children:		Mean age of children and (range) (years)
				Examined	Found microfilaraemic	
1	Adjumani	Subbe	728	217	0(0.0)	12.1(5-18)
2	Arua	Ajagoro	629	189	0(0.0)	11.2(5-17)
3	Arua	Aliba	1184	94	0(0.0)	12.7(5-17)
4	Arua	Goya	1218	115	20(17.4)	9.7(6-14)
5	Arua	Uleppi	1019	99	2(2.0)	10.8(5-16)
6	Moyo	Dufile	663	198	1(0.5)	11.4(6-17)
7	Moyo	Aliba	626	123	0(0.0)	11.2(5-18)
8	Yumbe	Okuyu	708	97	4(4.1)	10.8(5-18)
9	Yumbe	Pakayo	995	179	2(1.1)	11.1(6-18)
10	Nebbi	Alala	620	146	0(0.0)	11.8(5-17)
11	Nebbi	Pakadha	1636	49	0(0.0)	9.6(5-16)
12	Gulu	Min Akullo	1089	137	0(0.0)	9.6(6-13)
13	Pader	Kuywee	1080	176	2(1.1)	9.9(6-18)
14	Apac	Ogwangadar	1067	133	0(0.0)	9.1(6-18)
15	Kotido	Karenga	1409	99	0(0.0)	9.4(5-14)
16	Kotido	Komukuny	1537	95	0(0.0)	8.4(5-14)
17	Kotido	Lomodoch	1484	141	0(0.0)	13.3(6-18)
18	Kotido	Panyagara	1230	106	0(0.0)	9.0(5-17)
19	Kotido	Orwamuge	1121	256	5(1.9)	12.7(7-17)
20	Moroto	Kalotom	1195	82	0(0.0)	12.5(8-18)
21	Moroto	Kangole	1214	191	0(0.0)	14.2(10-19)
22	Moroto	Kapuat	1243	61	0(0.0)	10.3(7-14)
23	Nakapiripirit	Acegeretolum	1200	94	2(2.1)	11.9(5-16)
24	Nakapiripirit	Kalas Boys	1249	100	0(0.0)	10.4(5-19)
25	Nakapiripirit	Saint Mary's	1143	265	0(0.0)	11.9(5-19)
26	Sironko	Atari	1087	99	0(0.0)	6.9(5-16)
27	Sironko	Bukhalu	1086	213	5(2.3)	12.6(9-17)
28	Kumi	Oseera	1062	299	0(0.0)	10.8(5-19)
29	Pallisa	Oduai	1076	226	0(0.0)	10.1(5-16)
30	Tororo	Lubembe	1071	224	3(1.3)	10.8(5-19)
31	Tororo	Poyem	1112	224	10(4.5)	10.1(5-16)
32	Busia	Buloosi	1169	265	1(0.4)	10.4(5-17)
33	Iganga	Bwigula	1101	214	6(2.8)	10.6(5-15)
34	Jinja	Masese Co-ed	1189	255	2(0.8)	12.0(7-18)
35	Kamuli	Bugoodo	1085	223	9(4.0)	12.2(5-17)
36	Kamuli	Nkoone	1049	253	4(1.6)	9.7(6-18)
37	Kayunga	Galiraya	1069	102	3(2.9)	9.8(5-15)
38	Mukono	Kazinga	1146	99	29(29.3)	7.9(5-13)
39	Mukono	Namanoga	1075	260	100(38.5)	11.2(5-17)
40	Luwero	Balitta Wakyato	1104	180	90(50.0)	10.2(5-19)
41	Luwero	Kyambogo	1088	92	7(7.6)	7.7(5-15)
42	Nakasongola	Kisaalizi	1049	222	8(3.6)	11.2(5-19)
43	Kiboga	Bukwiri	1095	249	61(24.5)	12.4(6-17)
44	Mpigi	Kalwanga	1212	99	1(1.0)	9.1(5-15)
45	Mubende	Lusalira	1170	271	1(0.4)	9.2(5-16)
46	Masaka	Bukakata	1149	237	22(9.3)	10.6(5-15)
47	Rakai	Kayonza	1265	175	2(1.1)	9.1(5-15)
48	Rakai	Matengeeto	1198	149	35(23.5)	9.2(5-19)
49	Kalangala	Bugoma	1154	99	0(0.0)	9.9(5-15)
50	Kalangala	Lulamba	1137	100	1(1.0)	9.7(5-16)

[study sites 73–76 in the Table; see also Figure 1 in Onapa *et al.* (2005)] — were included in the study population. The overall study population thus consisted of 12,207 children (6083 boys and 6124 girls) from 76 study sites located in 49 of the 56 districts into which Uganda is currently divided. More than half (57.9%) of the subjects were aged 10–14 years, and most (91.2%) were aged 6–15 years (Fig. 1). The mean age of the subjects, which was 11.1 years overall, varied from 6.9 to 14.2 years at the different study sites (see Table).

Geographical Distribution of Microfilaraemia

Microfilariae of *W. bancrofti* were found in only six specimens: one from each of sites 6, 14, 19 and 76, and two from site 13. All the

other mff observed were *M. perstans*. Children with *M. perstans* microfilaraemias were detected at 47 (61.8%) of the 76 study sites, with prevalences ranging from 0.4% to 72.8% (see Table). The prevalences of *M. perstans* microfilaraemia were <5% at 33 (70.2%) of the 47 *M. perstans*-positive sites.

A map of the prevalences of *M. perstans* microfilaraemia in Uganda, showing the prevalences at the 76 study sites as well as prevalence contours created by geostatistical interpolation (ordinary kriging) of the empirical data, was produced (Fig. 2). This shows a broad, east–west-oriented belt of high endemicity stretching across the central part of the country, from the southern end of Lake Albert to the north–western shores of Lake Victoria. The highest prevalence in this belt was recorded in

TABLE. (continued.)

Study site	District	School name	Altitude (m)	No. and (%) of children:		Mean age of children and (range) (years)
				Examined	Found microfilaraemic	
51	Mbarara	Rwobuziizi	1384	235	1(0.4)	13.1(8–19)
52	Mbarara	Rweiziringo	1409	90	0(0.0)	10.7(5–18)
53	Mbarara	Murema	1362	82	0(0.0)	11.3(5–18)
54	Ntungamo	Kitwe Mixed	1373	221	1(0.4)	12.6(7–19)
55	Kabale	Bufuka	1965	215	0(0.0)	12.1(5–19)
56	Kisoro	Chihe	1809	96	0(0.0)	10.0(6–15)
57	Kanungu	Kibimbiri	1094	253	12(4.7)	12.5(6–18)
58	Kanungu	Rugyeyo	1761	166	0(0.0)	12.4(6–18)
59	Bushenyi	Rutaka	1195	245	2(0.8)	10.9(5–19)
60	Kasese	Katojo	1005	97	9(9.3)	11.6(5–18)
61	Kamwenge	Bukurungo	916	243	9(3.7)	12.0(7–18)
62	Kabarole	Kakooga	1547	231	8(3.5)	12.0(6–18)
63	Bundibugyo	Ntandi	706	246	179(72.8)	11.2(5–18)
64	Hoima	Bungoma	1170	222	90(40.5)	11.5(6–16)
65	Masindi	Butiaba	621	48	0(0.0)	13.3(6–17)
66	Masindi	Kilanyi	1108	50	2(4.0)	8.0(6–11)
67	Masindi	Kinyonga	962	223	5(2.2)	11.2(5–18)
68	Kibaale	Lubiri	1163	100	30(30.0)	11.0(5–17)
69	Kabale	Kamwezi	1494	99	0(0.0)	11.6(5–17)
70	Mubende	Namutamba	1372	101	5(5.0)	10.4(8–14)
71	Nakasongola	Kinoni	1074	99	3(3.0)	8.5(5–14)
72	Apac	Igoti	1039	94	1(1.1)	7.2(6–11)
73*	Kaberamaido	–	1113	155	3(1.9)	13.1(5–19)
74*	Katakwi	–	1084	158	5(3.2)	12.1(5–19)
75*	Lira	–	1083	81	8(9.9)	14.2(5–19)
76*	Kapchorwa	–	2048	86	0(0.0)	12.1(5–19)

*Data from the community surveys of Onapa *et al.* (2001a, b).

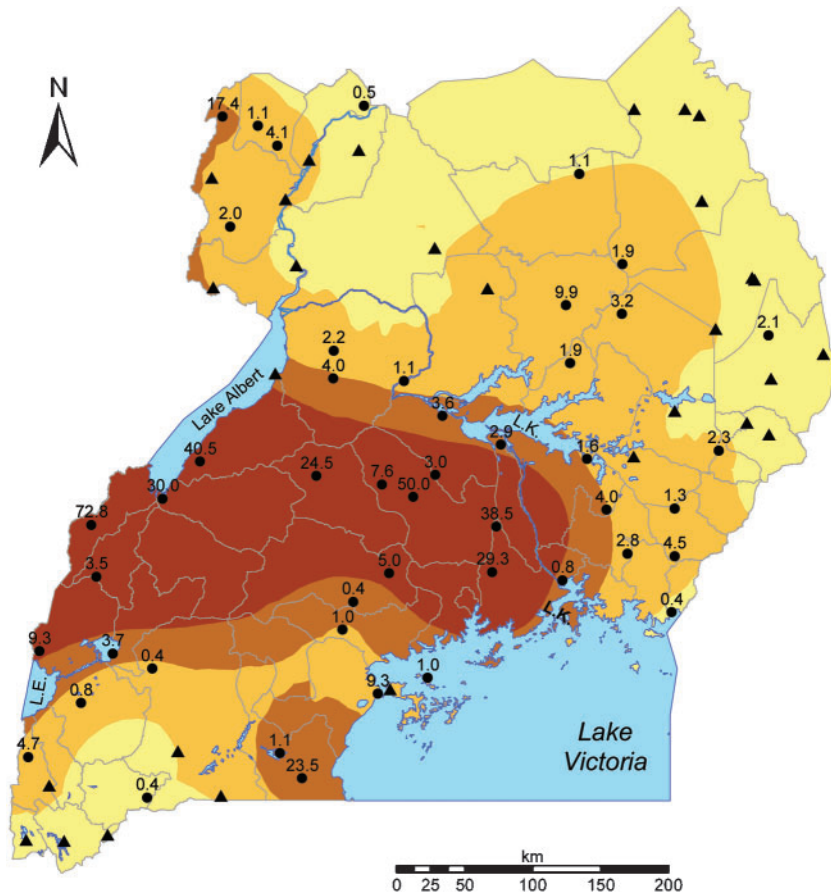


FIG. 2. District map of Uganda, showing the prevalences (%) of *Mansonella perstans* microfilaraemia recorded at the 76 study sites, as well as the prevalence contours created by spatial analysis (ordinary kriging) of the empirical data. The contours indicate areas with microfilarial prevalences of $\leq 1.0\%$ (□), 1.1%–5.0% (■), 5.1%–10.0% (■) and $>10.0\%$ (■). No values for prevalence are shown for the sites where no microfilaraemic children were found (▲). L.K., Lake Kyoga; L.E., Lake Edward.

Bundibugyo district, to the south of Lake Albert (site 63; 72.8%). Two other smaller foci, with fairly high prevalences of microfilaraemia, were found in Arua district (site 4; 17.4%), in the north-western corner of the country bordering the Democratic Republic of Congo and the Sudan, and in Rakai district (site 48; 23.5%), in the extreme south, near the border with Tanzania. Other pockets with moderately high prevalences occurred near Lake Edward (site 60; 9.3%), on the western shores of Lake Victoria (site 46; 9.3%), and north of Lake Kyoga (site 75; 9.9%).

The counts of the *M. perstans* mff in the positive thick smears revealed that 66.6% of

the 811 children found to have *M. perstans* microfilaraemias had 10–50 mff/ml blood, whereas 31.1% had 60–990 mff/ml and the other 2.3% had 1000–2820 mff/ml.

When the different kriging prevalence zones were projected to a digital model of the human population of Uganda in 2002, it was found that 20.4 million people (82.6% of the total population of 24.7 million in 2002) lived in areas where $>1\%$ of the school-aged children had *M. perstans* microfilaraemias. At the same time, 11.1 million people (44.9% of the population) and 6.8 million people (27.5%) lived in areas where the prevalences of *M. perstans*

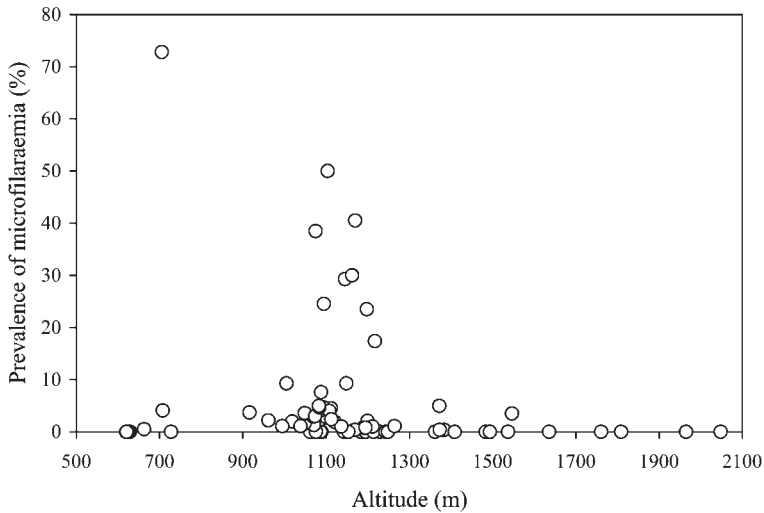


FIG. 3. The relationship between altitude and the prevalence of *Mansonella perstans* microfilaraemia among school-aged children at the 76 study sites.

microfilaraemia among the school-aged children were >5% and >10%, respectively.

Prevalence of *M. perstans*

Microfilaraemia in Relation to Altitude

The study sites were located at altitudes ranging from 620 (site 10) to 2048 m (site 76) above sea level (see Table). The relationship between the observed prevalence of *M. perstans* microfilaraemia among the school-aged children and altitude is shown in Figure 3. The highest site with *M. perstans* microfilaraemics lay at 1547 m above sea level (site 62; prevalence=3.5%). Although prevalences of >5% were only seen at altitudes of <1300 m, at these lower altitudes there appeared to be no clear relationship between altitude and *M. perstans* prevalence.

DISCUSSION

Despite its wide-spread occurrence in sub-Saharan Africa, little is known about the geographical distribution and prevalence of *M. perstans* infection in most parts of this region. The present survey was a straightforward and relatively simple addition to an attempt to map the geographical

distribution of *W. bancrofti* in Uganda (Onapa *et al.*, 2005). Although most of the children who were asked to provide one small blood sample (to be used for the assays of *W. bancrofti* antigens) readily agreed to provide a second sample (to be examined for *M. perstans* mff), some children, especially in the older age-groups, refused to have a second sample collected. At many of the study sites, therefore, the subjects for the *M. perstans* survey were fewer in number and generally younger than those for the *W. bancrofti* survey.

Information about school enrolment and school attendance was generally not available, but it is likely that most children who do not attend come from households of relatively low socio-economic status and therefore have a higher-than-average chance of being infected. The prevalences reported here should thus be considered minimum values for school-aged children. In general, attendance was relatively poor in the youngest and oldest age-groups considered and higher among those aged 10–14 years (unpubl. obs.). This trend is reflected in the age distribution of the children examined (Fig. 1).

Examination of the bloodsmears indicated that *M. perstans* was widely distributed

in Uganda. Microfilaraemics were detected at most (>60%) of the study sites, with prevalences ranging from 0.4% to 72.8%. Although the prevalence of *M. perstans* microfilaraemia fell below 5% at many of the sites, a broad belt of high endemicity, from Bundibugyo (south of Lake Albert) in the west to Mukono (on the north-western shores of Lake Victoria) in the east, was identified. Christy (1903), Fischer *et al.* (1996) and Tawill *et al.* (1995) all reported *M. perstans* infections from within this belt. Prevalences generally decreased to the north and south of this belt, but high-prevalence foci were also identified in the far north-western (Arua district) and south-eastern (Rakai district) corners of the country. The northern, eastern and south-western regions generally showed little or no *M. perstans* microfilaraemia.

By using kriging prevalence contours, in combination with data from a digitized model of the 2002 population, it was estimated that, in 2002, about 20.3 million individuals (82.6% of the national population) lived in areas where >1% of the school-aged children had *M. perstans* microfilaraemias, and about 6.8 million (27.5%) lived in areas with >10% prevalence. The population actually at risk of *M. perstans* infection is difficult to assess, as the minimum prevalence of microfilaraemia necessary for (significant) transmission to occur is unknown. In endemic populations, the prevalence of *M. perstans* microfilaraemia is known to increase progressively with age (Kershaw *et al.*, 1953; Gryseels *et al.*, 1985; Noireau *et al.*, 1990; Mommers *et al.*, 1994) and may reach very high levels in adults. In endemic communities of Zaire, for example, Gryseels *et al.* (1985) found prevalences of 36.2% in children (aged 5–19 years) and of 61.5% in adults (aged ≥ 20 years). Similarly, in a village in Cameroon, Mommers *et al.* (1994) reported prevalences of 19.0% in children (aged 10–19 years) and of 40.7% in adults (aged ≥ 20 years). Prevalences observed in school-aged children are therefore likely to be under-estimates of the overall community prevalences in any surveyed area.

In some of the most endemic areas of Uganda it seems probable that the whole adult population is infected with *M. perstans* — a situation similar to that found by Kershaw *et al.* (1953) in parts of Cameroon. Although it is difficult to estimate how many residents of Uganda are infected with *M. perstans*, this species appears to be the most prevalent human filarial infection in Uganda, outnumbering both *W. bancrofti* (Onapa *et al.*, 2005) and *Onchocerca volvulus* (Ndyomugenyi, 1998).

In Uganda at least, the geographical distribution of *M. perstans* did not appear to be primarily determined by altitude, although the prevalences of *M. perstans* microfilaraemia (among school-aged children) were low at sites that lay >1300 m above sea level (Fig. 3). Most areas with medium to high prevalences were within forest or formerly-forested areas. The study site, in Bundibugyo district, that had the highest endemicity is located in a tropical forest zone, with moist, semi-deciduous vegetation. The high-prevalence areas in the regions of Mukono and Luwero, and the north-western focus in Arua region, also fall within forest zones. Christy (1903) suggested a link between *M. perstans* prevalence and vegetation in Uganda, and associated high-prevalence areas with forests and the cultivation of bananas. Although the species of *Culicoides* transmitting *M. perstans* in Uganda, and their bionomics, are unknown, it appears likely that forests provide suitable habitats for the vectors. Khamala and Kettle (1971) listed 31 species of *Culicoides* from Uganda and several of them, including *C. grahamii*, are found in areas where *M. perstans* is endemic and might therefore be involved in the parasite's transmission. *Culicoides grahamii* has already been incriminated as a vector of *M. perstans* in forest regions of the Congo (Noireau *et al.*, 1990) and Cameroon (Kershaw *et al.*, 1953).

Elsewhere in Africa, vegetation has also been found to be influential in the distribution and prevalence of *M. perstans* (Kershaw

et al., 1953; Gryseels *et al.*, 1985), with highest prevalences being observed in forest zones, where the vectors breed in decomposing plant matter. Further analyses of the present data, incorporating the use of a geographical information system, will be used in an attempt to determine more accurately the role of climatic and environmental factors in the distribution of *M. perstans* in Uganda.

All the blood samples for the *M. perstans* survey were collected during the day time. Apart from a few mff of *W. bancrofti* (which have nocturnal periodicity in Uganda), only those of *M. perstans* (which are non-periodic) were seen. *Loa loa*, which has diurnal periodicity and has been reported in Uganda (Poltera, 1973), was not observed in the present study. Like *M. perstans*, *L. loa* is more prevalent in adults than in children (Kershaw *et al.*, 1953; Gryseels *et al.*, 1985; Mommers *et al.*, 1994), and it is possible that it was not detected in the present survey because only children were screened. It is also possible that ecological changes or sustained tsetse-control activities (Wooff, 1968) could have interrupted transmission of *Loa* in much, if not all, of Uganda. Finally, it is also possible that, as suggested by Baird *et al.* (1988), the Ugandan parasites previously identified as *L. loa* were *M. perstans* or *W. bancrofti*.

The geographical distribution of *M. perstans* microfilaraemia (Fig. 2) was found to differ markedly from that of *W. bancrofti* infection (Onapa *et al.*, 2005), probably reflecting the different requirements of the vectors of the two species. The geographical distributions of the two species of filariae overlapped in some areas but the prevalences of *M. perstans* microfilaraemia were usually high when the prevalences of *W. bancrofti*-specific antigenaemia were low, and *vice versa*. As *M. perstans* is not readily affected by any antifilarial drug that is frequently used (Strohschneider, 1953; Fischer *et al.*, 1996), *M. perstans* microfilaraemias may remain common in areas targeted for mass administrations of such drugs by the Ugandan Programme for the Elimination of Lymphatic Filariasis. Such microfilaraemia

may cause concern, and perhaps confusion, among health workers and the beneficiary communities. General awareness about *M. perstans* infection, and the methods for distinguishing the microfilaraemias of *M. perstans* from those of *W. bancrofti*, needs to be raised in Uganda, especially in areas where the two species are co-endemic. In discussions on the possible, future employment of antibody assays for monitoring progress in programmes for the control of lymphatic filariasis (Lammie *et al.*, 2004) or onchocerciasis (Rodriguez-Pérez *et al.*, 2003), it is important that potential cross-reactions with antibodies induced by *M. perstans* infections are borne in mind.

Although *M. perstans* is among the most common helminth parasites of humans in Africa, little is known about the public-health implications of *M. perstans* infections in endemic populations. Many clinical manifestations have been associated with *M. perstans* infections but most of these have been observed in expatriates and tourists who have visited endemic areas (Adolph *et al.*, 1962). There appear to have been no systematic studies to determine the morbidity attributable to *M. perstans* in endemic populations, and *M. perstans* remains one of the least understood filarial infections in terms of epidemiology, morbidity, treatment and control. The possibility that human infection with *M. perstans* can affect the host's response to co-infection with other pathogens, and the host's response to treatment of these, also needs careful consideration and exploration. *Mansonella perstans* is a wide-spread but neglected parasite to which more attention should be paid.

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