GEOGRAPHIC DISTRIBUTION AND EPIDEMIOLOGY OF 
OESOPHAGOSTOMUM BIFURCUM AND HOOKWORM INFECTIONS IN 
HUMANS IN TOGO

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Abstract. In contrast to the rest of the world, infections with Oesophagostomum bifurcum are commonly found 
in humans in northern Togo and Ghana. In addition, infections with hookworm are endemic in this region. In the 
present study, a detailed map of the geographic distribution of O. bifurcum and hookworm infections in northern 
Togo was made. There were a number of foci with high prevalence of infection with O. bifurcum. All the villages 
examined were infected with hookworm, and the distribution was quite patchy. Women were infected with O. bifurcum 
more often than men, while infections with hookworm were more prevalent in men than in women. The prevalence 
and intensity of infection with both parasites were clearly age-dependent. We estimate that more than a 100,000 
people in Togo are infected with O. bifurcum and more than 250,000 are infected with hookworm.

Oesophagostomum bifurcum is a common intestinal nematode of monkeys. Until 1986, infections in humans were 
considered as a rare zoonosis. In northern Togo and Ghana, however, O. bifurcum infections are known to be more than 
incidental infections among the population. The pathology of O. bifurcum infections is caused by the encapsulation of 
the larvae in the intestinal wall; here the larvae develop into young adult worms before re-entering the intestinal lumen 
to start egg production. Outside the host, in a moist environment, these eggs develop into third-stage larvae, which 
have to be ingested by a new host. It is not surprising that the highest prevalences of infection are measured during and 
shortly after the rainy season. Transmission is oral, but the behavior that promotes transmission is little understood.

Preliminary data based on rather haphazard, nonrandom, 
surveys in northern Togo and Ghana estimated that 30% of 
the population was infected with O. bifurcum, and in some 
villages prevalences > 50% were found. The distribution of 
the parasite seems to be very focal, being abundant in this 
region and almost absent elsewhere. Even in Togo itself, 
clinical cases, frequently seen in Dapaong, are never seen 
further to the south. In the same region, hookworm infections, 
99% of which are caused by Necator americanus 
(Blotkamp J, unpublished data) are highly endemic.

To achieve a better understanding of the distribution and 
possibly its underlying causes, the present study sought to 
create a detailed map of the geographic distribution of O. 
bifurcum and hookworm infections in northern Togo (Figure 1). Furthermore, the gender- and age-dependent prevalences 
and intensities of infections with O. bifurcum and hookworm 
are reported such that more insight in the way of transmission (i.e., oral versus percutaneous) and the reason for this 
confined distribution of the parasite might be obtained. The investigation constitutes a surveillance baseline for O. bifurcum 
and hookworm infections in the area, which is relevant to the design of control measures.

MATERIALS AND METHODS

Study area. To avoid the influence of seasonal fluctuations of prevalence and intensity of infection, the survey was 
conducted in a short period, between August and November 1997 in northern Togo, an area of approximately 4,220 km². 
Dapaong is the main town in this region. The area is sub-Saharan, consisting of open savannah that is dry and rocky 
with a few trees. In the villages, the houses are scattered over farmlands. The population of the study area is approxi-

mately 336,000 inhabitants. The research area was limited by latitude 10°27'N to the south, Ghana to the west, Burkina 
Faso to the north, and Benin to the east. To achieve a geographically homogenous distribution of the villages over 
northern Togo, the area was divided into areas of 18 × 19 km. In each of these areas, 4 villages were selected. Prior to 
stool collection, informed consent was obtained from 80 individuals per village from 20 different households. From 
each household, a man and a woman between 20 and 60 years old and a boy and a girl between 5 and 19 years old were asked to give their name, age, and sex. A similar procedure was applied in a parallel study in Ghana to enable 
comparison of the observations in countries (Dery G, Yelifari L, unpublished data). Ten infants (0–4 years old) per 
village were also added to the survey. The study was approved by the Ethical Committee of the Netherlands Orga-
nization for Scientific Research in the Tropics and the Togolese Ministry of Health.

Stool collection and parasitologic diagnosis. Individually 
labeled plastic containers for stool collection were distributed to the study participants and collected the next day. 
The eggs of O. bifurcum are morphologically identical to those of hookworm. Only the third-stage larvae of both parasitesc obtained by coproculture have distinguishable morphologic features. Therefore, a modified coproculture was 
made of 2 grams of stool per individual, as described elsewhere. Larvae were identified by species and individually 
counted to a maximum of 100 per coproculture. The intensity of infection was quantified by classification of the larval 
counts as previously proposed.

Statistical methods. Data from Dapaong were considered separately from the rest of the data obtained from individuals 
living in the rural area. The data collected from the infants were also considered separately. Prevalences of infection 
are given as the percentage parasitologically positive individuals.
in the population examined. Individuals were grouped into 7 age categories of 5-year intervals in the children and 10-year intervals in the adults. Differences in prevalences between gender and age classes were analyzed by chi-square tests. Differences in intensity of infection between gender and age-classes were analyzed by the Mann-Whitney and Kruskal-Wallis non-parametric methods. An association between *O. bifurcum* and hookworm on a village and individual level were measured by the Pearson’s correlation coefficient and Kendall’s rank correlation, respectively.

**RESULTS**

Sixty-five villages were examined in this survey. Readable cultures were available from 75% of the distributed stool containers, and stool samples were obtained from 3,659 individuals. The research was done towards the end of the rainy season and people were working in the field; therefore, some failed to return their containers.

Over the entire region 29.5% of the population was infected with *O. bifurcum* and 70.3% were infected with hookworm. This is likely to be an underestimate of the true prevalence, since very light infections are easily missed with a single coproculture (Pit DSS and others, unpublished data). In Dapaong, 266 individuals from different areas of the town participated in the survey; 12% were infected with *O. bifurcum* and 49% were infected with hookworm.

**Gender- and age-related prevalences and intensities of infection.** Overall, significantly more women were infected with *O. bifurcum* than men (34% versus 25%; $\chi^2 = 40.4, P < 0.001$) (Figure 2, top), but the difference was only significant in adults more than 20 years old ($\chi^2 = 12.5, P < 0.001$). Infection with hookworm, on the other hand, was significantly more prevalent among males than females (73% versus 68%; $\chi^2 = 35.4, P < 0.001$) when the total population was considered. However, when the population was grouped by age, such differences were significant only in children 5–9 years old ($\chi^2 = 4.5, P < 0.05$) (Figure 2, bottom).

Prevalence and intensity of infection with *O. bifurcum* and hookworm were clearly age-dependent. The prevalence of infection with *O. bifurcum* increased sharply until the age of 14, reaching a maximum of 43%. The prevalence and intensity of infection then decreased slightly and maintained a plateau throughout adulthood (Figure 3, top). The prevalence of infection with hookworm reached its maximum of 80% infected in those 15–19 years old, and then stabilized at approximately 71% in adults (Figure 3, bottom). Heavy infections (> 30 larvae per coproculture) were also most frequently seen in this age group.

Thirty percent of the young children (0–4 years old) were already infected with hookworm. Figure 4 shows the rapid increase in the prevalence of infection with hookworm in these children; almost 10% of the infants younger than 1 year of age were already infected, and half of those 4 years old were also infected. The prevalence of infection with *O. bifurcum* increased less dramatically in infants, but infection was prevalent in more than 10% of the 4-year-old children.

**Geographic distribution of *O. bifurcum* and hookworm.** Figure 5 shows the geographic distribution of the villages where *O. bifurcum* is prevalent. There are a number of foci with a high prevalence of infection with *O. bifurcum*. The highest prevalence of infection (78%) was measured in Dassoute, close to the Ghanaian border. In northern Ghana, a highly endemic area is found adjacent to the highly endemic area in Togo (Dery G, Yelifari L, unpublished data).
There is a band of villages of low endemicity in Togo from the northeast toward the northwest. Three additional villages (Kougniére, Magnan, and Payouka) just south of the research region (70 km south of Dapaong) have also been investigated. Larvae of *O. bifurcum* were not found in coprocultures, but 57% of the population examined (n = 190) were infected with hookworm.

Figure 6 shows the distribution of the villages where hookworm is prevalent. Every village examined in northern Togo was infected with hookworm: the lowest prevalence of infection (11%) was found in Koundjouare close to the border with Benin, while the highest prevalence (96%) was measured in Batambore, south of Dapaong. The distribution was quite patchy.

At the village level there was a significant correlation between the prevalence of infection with *O. bifurcum* and hookworm (Pearson’s correlation coefficient = 0.569, *P* < 0.001). Also within an infected village, there was a significant rank correlation between the larval counts of *O. bifurcum* and hookworm at the individual level (Kendall rank correlation = 0.324, *P* < 0.001).

DISCUSSION

Over the entire region 29.5% of the population was infected with *O. bifurcum* and 70.3% was infected with hookworm. However, these high prevalences of infection with *O. bifurcum* are not suggestive for recent transmission and a newly emerging parasitic infection. The prevalences appear remarkably stable when compared with the prevalences found in those villages where *O. bifurcum* infections were first recognized some 9 years ago (Table 1). Although plant anthelmintics and modern drugs are used, community based parasite control has never been attempted in the region and inadequate sanitation, poor hygiene, and walking barefoot are the factors responsible for the persistence of transmission of *O. bifurcum* and hookworm in the region.

The prevalence and intensity of infection with *O. bifurcum* and hookworm increased rapidly with age and remained at a plateau in teenagers and adults. This pattern of prevalence is typical for intestinal nematode helminth parasites in communities with stable endemic infection, and resembles those reported elsewhere for hookworm infections. Differences in prevalence and intensity of infection could be due to age-dependent transmission, acquired resistance, or a combination of the two processes. Unlike other helminth infections, there does not seem to be a correlation between worm load and pathology with *O. bifurcum*, but intensity of infection is a more precise parameter to quantify infection and transmission than prevalence of infection alone.

The geographic distribution of *O. bifurcum* and hookworm infections in northern Togo is not entirely random, but seems confined to a number of high transmission foci. Since *O. bifurcum* infections were not found in the villages south of latitude 10°27’N, *O. bifurcum* seems to be really confined to the northern region of Togo and neighboring Ghana. Southern Burkina Faso and northern Benin have not yet been examined. Undoubtedly, factors such as soil characteristics, altitude dependent micro-ecology, and subtle variations in host behavior contribute to the geographic distribution of both parasites, but clear associations between these variables and infection are not yet recognized. Despite different transmission modes of *O. bifurcum* and hookworm, (oral versus...
FIGURE 5. Geographic distribution of *Oesophagostomum bifurcum* in northern Togo. Each square represents a village indicating the prevalence of infection. The darkness of the color corresponds to the prevalence of infection.

FIGURE 6. Geographic distribution of hookworm in northern Togo. Each square represents a village indicating the prevalence of infection. The darkness of the color corresponds to the prevalence of infection.
O. bifurcum and hookworm infections in Togo

There is a correlation between the prevalences and intensities of infection with both species, not only at the individual but also at the village level. The latter association suggests that environmental factors that determine survival of the free-living larval stages of both species may play a role in addition to behavioral and hygienic factors. Preliminary attempts to correlate the patchy distribution of both nematodes with differences in geologic, vegetation, and climatologic characteristics of the area (based on detailed maps) were unsuccessful. Further and more refined studies are required to understand the foci of the distribution of these parasites.

The rural population of northern Togo is estimated to be 336,000. Taking the age distribution and the age-specific differences in prevalence into account, it can be estimated that 101,000 people are infected with O. bifurcum and 237,000 are infected with hookworm. Although prevalence data should not be readily used to assess the dimensions of a public health problem, the abundance of this little known parasitic nematode in combination with its occasional severe pathology indicates that O. bifurcum is a locally common and important parasite in northern Togo. There is an urgent need to extend the distribution studies to the neighboring regions, and more clinical and epidemiologic information is needed to assess its public health importance and the priority for prevention and control.

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