

## Perspectives

### Dracunculiasis Eradication: Neglected No Longer

Donald R. Hopkins,\* Ernesto Ruiz-Tiben, Philip Downs, P. Craig Withers, Jr., and Sharon Roy

*The Carter Center, Atlanta, Georgia; Division of Parasitic Diseases, National Center for Zoonotic, Vector-Borne, and Enteric Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia*

**Abstract.** This report summarizes the status of the global Dracunculiasis Eradication Program as of early 2008. By the end of 2007, dracunculiasis (Guinea worm disease) transmission had been eliminated from 15 of the 20 countries where the disease was endemic in 1986, only 9,585 cases were reported worldwide, and 2,016 villages still had indigenous cases of the disease. Two of the remaining affected countries (Nigeria and Niger) reported < 100 cases in 2007 and are on the verge of eliminating dracunculiasis if they have not stopped transmission already. Sudan, Ghana, and Mali are addressing their final challenges to interrupting all remaining transmission by the end of 2009.

#### INTRODUCTION

The global Dracunculiasis Eradication Program has continued its progress toward the goal of stopping transmission of dracunculiasis (Guinea worm disease). The status of the initiative was last reviewed here 3 years ago.<sup>1</sup> This paper summarizes the status of the program as of April 2008.

We described in previous reports the parasite and the strategies and interventions being used to eradicate it.<sup>1,2</sup> The infection (dracunculiasis or Guinea worm disease) is caused by the nematode parasite *Dracunculus medinensis* and is transmitted to humans in contaminated drinking water containing copepods (water fleas) that harbor infective larvae of the parasite. The larvae are expelled into water by adult female worms that emerge through the skin of infected persons ~1 year after infection. Emergence, the act of manually removing the Guinea worm, is slow, painful, and disabling (although usually not fatal), and therein lies its serious adverse socioeconomic impact on the health, agricultural productivity, and school attendance of affected populations. Persons are incapacitated for periods averaging 2–3 months, and more than one half of a village's population may be affected simultaneously during the main harvest or planting season. Humans are the only reservoir of infection. Individual infections last only 1 year, but people do not develop immunity to the parasite. There is not an effective treatment or vaccine, but the infection may be prevented by educating villagers about the origin of the disease and about the need to prevent infected persons from entering sources of drinking water and to always filter their drinking water through a finely woven cloth that removes the copepods; by using ABATE larvicide (temephos; BASF Corp., Mount Olive, NJ) to kill the copepods and larvae in ponds and other stagnant sources of drinking water; and by providing clean drinking water from safe sources such as protected hand-dug wells or borehole wells.

This global eradication campaign began at the Centers for Disease Control and Prevention (CDC) in 1980, was adopted as a sub-goal of the International Drinking Water Supply and Sanitation Decade (1981–1990), and has been led since 1986 by The Carter Center, at the head of a coalition that includes the ministries of health of the endemic countries, CDC, the World Health Organization (WHO), and the United Nations

Children's Fund (UNICEF) as major partners and thousands of village volunteers and supervisory health staff and is supported by numerous donor agencies, governments, foundations, and other institutions. At the World Health Assembly in 2004, ministers of health of the remaining endemic countries set a target to stop transmission of dracunculiasis by the end of 2009.<sup>3</sup>

#### CURRENT STATUS OF THE CAMPAIGN

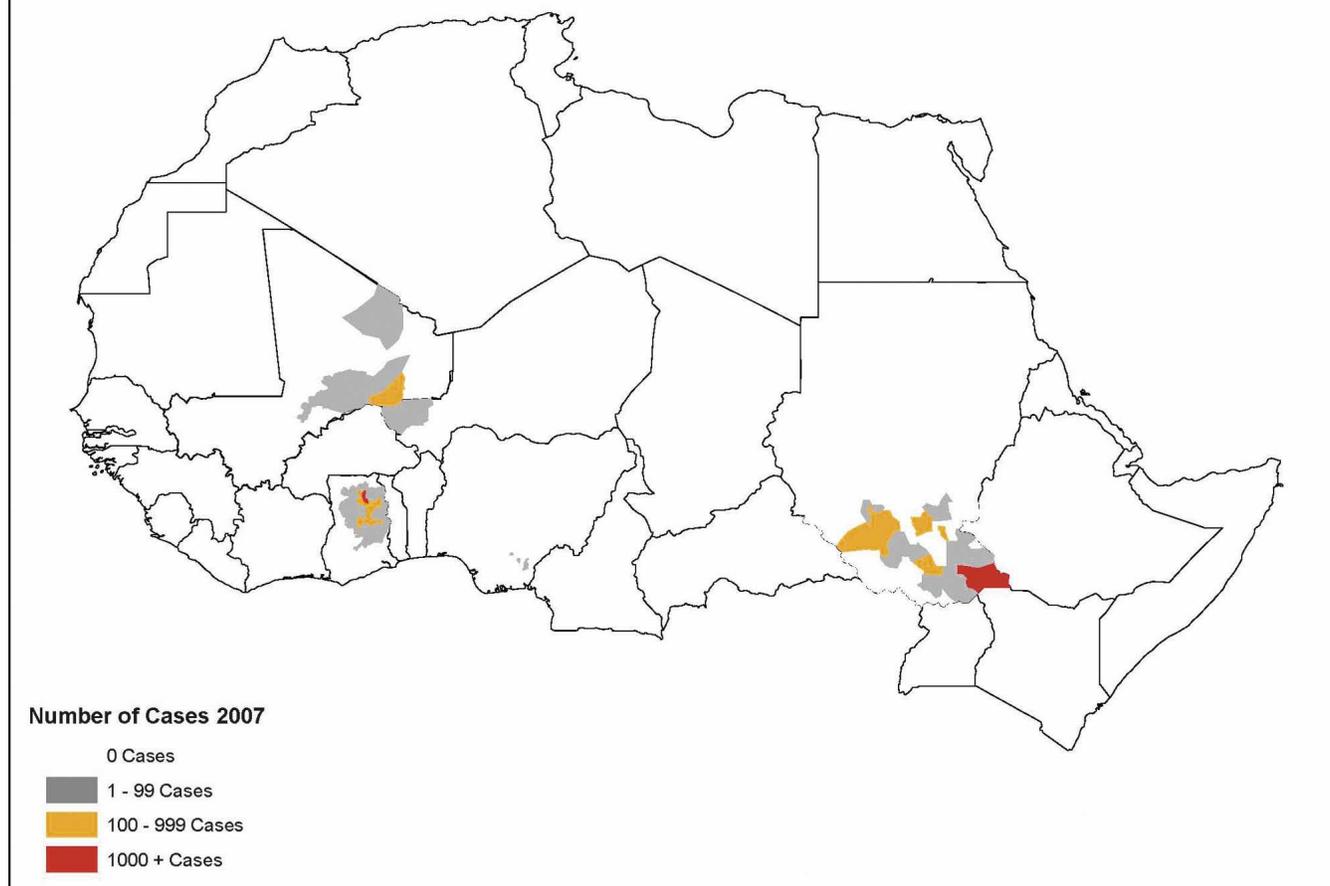
At the end of 2007, cases of dracunculiasis had been reduced to 9,585 cases reported, the first time < 10,000 cases were reported in a year (from an estimated 3.5 million cases in 1986 and 16,026 in 2004), the number of endemic villages remaining was 2,016 (from 23,735 in 1993 and 3,109 in 2004), and the number of countries with endemic disease was down to only 5 (from 20 in 1986 and 11 in 2004). Four countries reported zero indigenous cases for the first time in 2007 (Burkina Faso, Côte d'Ivoire, Ethiopia, Togo), joining Benin and Mauritania that reported zero cases for the first time in 2005 (Figure 1). The number of cases reported during the first four months of 2008 is 84% less than the number of cases reported during the same period of 2007 (Figure 2). The number of cases exported from one country to another has been reduced from a peak of 154 in 2002 to 114 in 2004 to 15 in 2007 (Figure 3).<sup>4</sup>

Of the five remaining countries, Niger, which reported 11 indigenous cases in 2007, and Nigeria, which reported 73 indigenous cases, may have seen their last cases already. Nigeria reported 37 cases in January–March 2008, from five villages, but all of the cases occurred in, or were exported from, a single village, and all 37 cases were detected before or within 24 hours of emergence of the worm(s) and were contained successfully. Niger's most recent indigenous case was reported in November 2007, and since then (January–April 2008) only one case, imported from Mali and contained, was reported (in February). Sudan, Ghana, and Mali reported 61%, 35%, and 3%, respectively of all cases in 2007, reflecting the three main foci of endemic disease that remain in southern Sudan, northern Ghana, and eastern Mali.

**Sudan.** Sudan has greatly intensified interventions against dracunculiasis since the Comprehensive Peace Agreement was signed in January 2005 to officially end the more than two-decade long civil war. In 2007, 22,322 villages were under surveillance by the Southern Sudan Guinea Worm Eradication Program (SSGWEP), of which 1,765 villages reported endemic disease. This program reported an increase to 15,539

\* Address correspondence to Donald R. Hopkins, The Carter Center, 453 Freedom Parkway, Atlanta, GA 30307. E-mail: sdsulli@emory.edu

## Distribution of 9,570 Indigenous Cases of Dracunculiasis: 2007



This map appears in color at [www.ajtmh.org](http://www.ajtmh.org).

cases in 2006, from 5,569 cases reported in 2005, as a result of reporting from endemic areas that became newly accessible after the official end of the civil war. The SSGWEP has deployed > 28,000 village volunteers, supervisors, and other health staff working on the program full time. In 2007, the SSGWEP reduced the number of cases reported by 63% compared with 2006 (to 5,815), and improved its rate of reporting to 70% of endemic villages (from 63% in 2006), whereas the proportion of interventions in 2007 is summarized in Table 1. The health ministers of Sudan and of southern Sudan both participated in a Program Review of Sudan's GWEP that was held at The Carter Center in November 2005, and former US President Jimmy Carter visited northern and southern Sudan in February 2007 to help encourage support for the program by political leaders. The SSGWEP recently appointed a retired bishop as eminent spokesperson and advocate for the campaign. Program Reviews were conducted in southern Sudan in December 2006 and January 2008 with support from The Carter Center, UNICEF, and WHO. Northern Sudan has reported no endemic cases of dracunculiasis since 2001. Sudan exported three cases to Ethiopia and four cases to Uganda in 2007.

**Ghana.** After more than a decade of stagnation, frustration, and many disappointments, Ghana's Guinea Worm Eradica-

tion Program finally began to achieve a long-sought decisive turn around in the program's effectiveness in April 2006, which began to be manifest in April 2007. Many changes lay behind the improved programmatic effectiveness, including better supervision and accountability, active oversight of patients daily by paid staff, and an intensified public awareness campaign in national and international media. Ghana's program gained an effective advocate when Miss Ghana 2005 elected to publicly support the GWEP by visiting endemic areas with administrative and public health leaders, an effort for which she was named Miss Beauty With a Purpose at the annual international competition that was held in Warsaw, Poland in 2006. The improvements accelerated after a Program Review held with the responsible Ghanaian health officials and in-country staff from The Carter Center, WHO, and UNICEF that was held at The Carter Center with participation by President Carter in August 2006. After that review, the Government of Ghana declared Guinea worm disease to be a public health emergency (in the northern region of Ghana), involved other relevant ministries in the campaign, and replaced several underperforming health staff, among other measures. A disastrous explosion of cases (caused by a breakdown of the water supply system for a major population area the year before, with local people resorting to con-

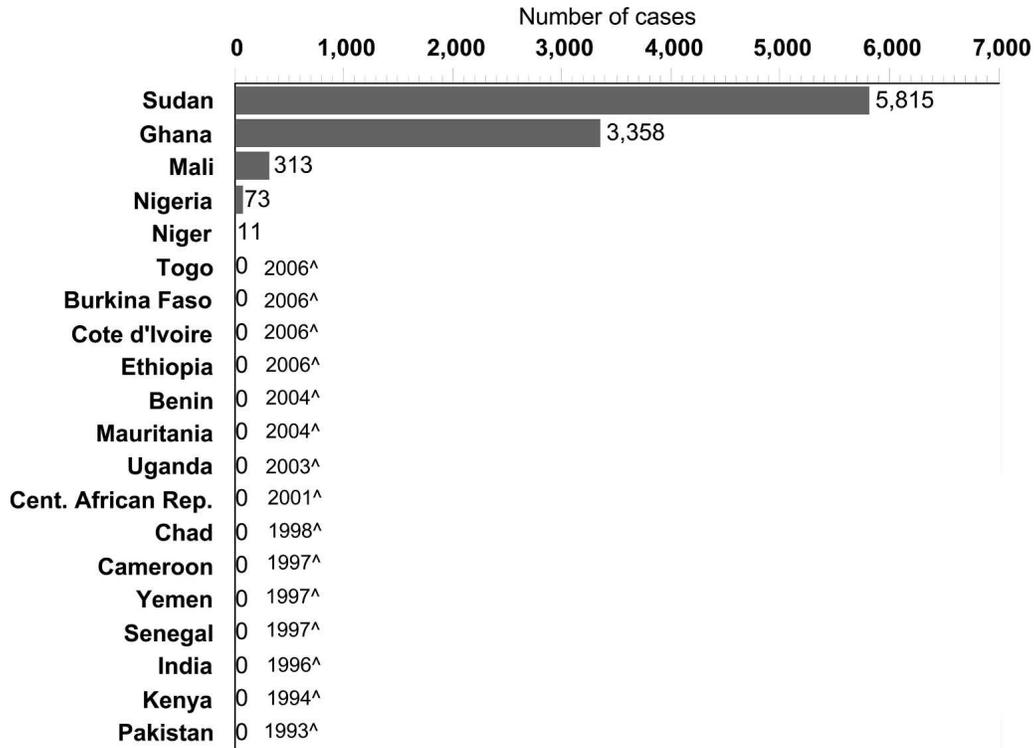


FIGURE 1. Distribution of 9,570 indigenous cases of dracunculiasis reported during 2007\* and year of last indigenous case in other countries. \* Excludes 15 cases exported from one country to another. ^ Year last indigenous case reported. Pakistan and India certified free of disease in 1996 and 2000, respectively, Senegal and Yemen in 2004, and Cameroon and Central African Republic in 2007.

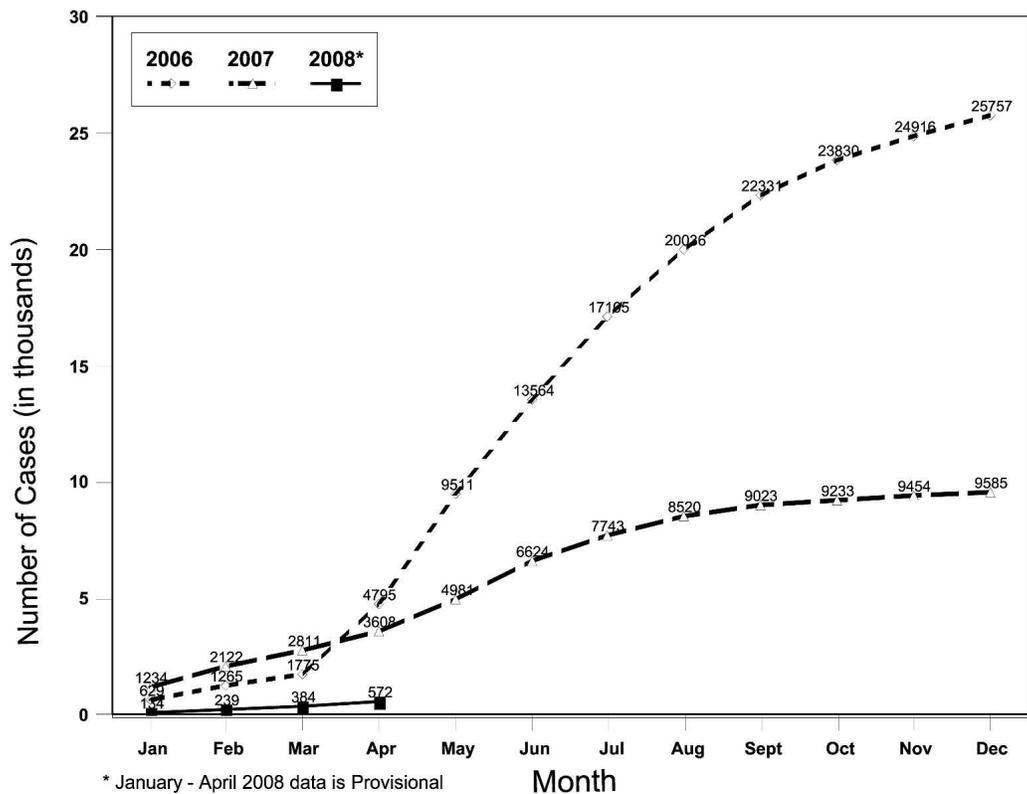


FIGURE 2. Cumulative number of reported cases of dracunculiasis in Ghana by year: 2006–2008.\*

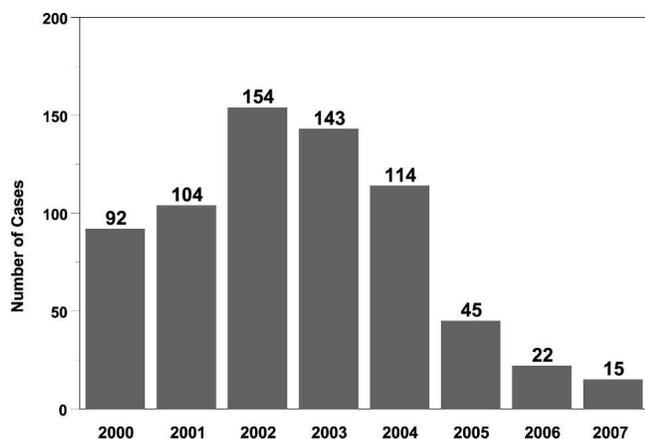


FIGURE 3. Number of exported cases of dracunculiasis during 2000–2007.

taminated sources of drinking water) that peaked in January 2007 shortly before a visit by President Carter in February and celebration of the Golden Anniversary of Ghana’s political independence in March was met by a determined onslaught of public health force. Although Ghana’s cases declined by only 19% overall between 2006 and 2007 (from 4,134 to 3,358 cases), the monthly rates of reduction increased steadily after April 2007 to an unprecedented level of 91% reduction in January–March 2008 compared with the first quarter of 2007 (from 2,215 cases to 200 cases). In 2007, the northern region reported 96% of all cases in Ghana, and all of the 26 villages with endemic transmission identified in January–March 2008 are in the northern region. In the northern region, 59% of cases were male, 59% were 15 years old or younger (many of whom were not enrolled in school), and 95% of the cases belong to the Dagomba ethnic group. The overall rate of cases contained has increased in Ghana from 60% in 2005 to 75% in 2006 and to 84% in 2007. The current status of interventions is summarized in Table 1. Ghana exported three cases to Burkina Faso and two cases to Togo in 2007.

**Mali.** Four of Mali’s regions (Kayes, Koulikoro, Segou, and Sikasso) are now free of dracunculiasis, whereas the disease is still endemic in the four other regions: Gao, Kidal, Mopti, and Timbuktu. Mali suffered two unexpected outbreaks of disease in 2007. The first outbreak began in a village in Kidal Region in June but was not reported by regional authorities to the national program until August, by which time none of the 86 cases confirmed then had been contained. Interventions were begun among a cooperative population that had not previously known the disease and was eager to get rid of it as quickly as possible. This outbreak originated from contamination of a local water source in 2006 by an infected koranic student who imported the disease from an endemic village in Gao Region and who was not detected or reported to the program. The second outbreak, which totaled 68 cases, occurred in three villages in Gao Region that were first brought to the attention of Mali’s inadequately attentive GWEP by cross-notification in 2007 of two cases that were exported to Niger from Mali and whose infections were detected in Niger when their worms began to emerge in 2007. Largely because of the late detection of these two outbreaks, the overall rate of case containment in Mali in 2007 was only

TABLE 1  
Dracunculiasis eradication campaign: status of interventions during 2007

Country	Number of reported cases (indigenous) in 2007	Number of reported cases (imported) in 2007*	Percent of all cases reported that were contained during 2007	No. of villages/localities where the program applied interventions during 2006 and 2007 (Groups I and II combined)†	Percent change in cases in villages/localities reporting cases in 2006: Groups I and II combined	2007			Status of interventions during 2006–2007					
						No. reporting one or more cases	No. reporting only imported cases	No. reporting indigenous cases	Villages where interventions applied: 2006–2007	Percent reporting monthly‡	Percent with filters in all households‡	Percent using Abate‡	Percent with one or more sources of safe water‡	Percent provided health education‡
Sudan	5,815	0	50%	1,997	-81%	1,998	233	1,765	3,023	70%	38%	11%	16%	93%
Ghana	3,358	0	84%	606	-26%	406	226	180	386	98%	70%	65%	47%	100%
Mali	313	0	36%	88	-71%	71	9	62	113	100%	100%	90%	27%	100%
Nigeria	73	0	60%	9	-81%	4	1	3	9	100%	100%	100%	100%	100%
Niger	11	3	93%	34	91%	9	3	6	19	100%	100%	100%	37%	100%
Togo	0	2	50%	10	-100%	2	2	0	10	100%	100%	100%	75%	100%
Côte d'Ivoire	0	0	0%	1	-100%	0	0	0	1	100%	100%	100%	100%	100%
Burkina Faso	0	3	33%	2	-100%	3	3	0	7	100%	100%	57%	43%	100%
Ethiopia	0	3	100%	1	-100%	3	3	0	5	100%	100%	100%	0%	100%
Total	9,570	11	61%	2,748	-70%	2,496	480	2,016	3,573	78%	48%	27%	24%	95%

\* Uganda reported four cases of dracunculiasis imported from Sudan during 2007.

† Group I are villages that reported one or more cases in both 2006 and 2007, and Group II are villages that reported one or more cases in 2006 but zero cases in 2007.

‡ The base of the percentage is the number of villages/localities where the program applied interventions during 2006–2007.

36%. The status of other interventions in Mali is summarized in Table 1. Mali reported a reduction in cases of only 3% between 2006 and 2007, from 323 to 313 indigenous cases, while exporting three cases of dracunculiasis to Niger in 2007.

**Global activities.** The global campaign has continued to convene an annual meeting of all endemic countries in March or April of each year, the most recent ones of which met in Accra, Ghana, in 2005; Niamey, Niger, in 2006; Ouagadougou, Burkina Faso, in 2007; and Abuja, Nigeria, in 2008. The three senior international advocates for dracunculiasis eradication, President Carter, Mali's President Amadou Toumani Toure, and Nigeria's former head of state General (Dr) Yakubu Gowon, participated in the same meeting for the first time at Abuja in April 2008. The Carter Center also held ceremonies to honor the eight latest countries to report zero indigenous cases for at least 12 consecutive months in Atlanta in November 2006 (for Benin, Central African Republic, Mauritania, and Uganda) and in Abuja in April 2008 (for Burkina Faso, Côte d'Ivoire, Ethiopia, and Togo). In recent years, the remaining endemic countries have convened Program Reviews that are still joined by international partners, but held mostly in-country about 6 months after the annual meeting of all endemic countries. A special review for all five (then) endemic francophone countries was held at The Carter Center in November 2006 and in Abidjan, Côte d'Ivoire, in September 2007.

Led by director-general Dr. Margaret Chan, the World Health Organization has stepped up its efforts in advocating vocally for eradication of dracunculiasis and polio. Dracunculiasis eradication was the subject of ministerial meetings attended by ministers from the remaining endemic countries and some formerly endemic countries during the World Health Assemblies in Geneva in 2006 and 2007, and the initiative was discussed at the meeting of WHO's Executive Board in January 2008 in preparation for another ministerial meeting at the World Health Assembly in May 2008.<sup>5,6</sup> The International Commission for the Certification of Dracunculiasis Eradication (ICCDE) held its sixth meeting in Geneva in March 2007, at which time it recommended certifying 12 more countries as free from transmission of dracunculiasis (including formerly endemic Cameroon and Central African Republic), bringing the cumulative total of countries and territories now so certified by WHO to 180.<sup>7</sup> Twenty-one countries remain to be certified, including the 5 still endemic countries in Africa and 16 countries in the pre-certification state, all but one of which (Cambodia) are also in Africa. The ICCDE and its chairman have also advocated recently for more attention to be paid to dracunculiasis eradication by the remaining endemic countries and WHO. The generous grant awarded to The Carter Center and WHO by the Bill & Melinda Gates Foundation in 2005 has greatly facilitated the work of both institutions and the endemic countries during the period covered by this update.

During 2004–2005, the WHO Collaborating Center for Research, Training, and Eradication of Dracunculiasis at CDC undertook research to provide molecular tools to distinguish *Dracunculus medinensis* from other tissue-dwelling nematodes, including other *Dracunculus* species that usually infect animals but on rare occasions also humans. Amplification, sequencing, and comparison of genes from the small-subunit ribosomal RNA (18S rRNA) of *D. medinensis* and *D. insignis* provided a basis for the molecular differentiation of *D. medi-*

*ensis* from other species.<sup>8</sup> The resulting molecular probe complements outcomes from traditional examination of the morphologic structures of worm specimens and also provides a basis for determining whether dracunculid worms of non-human origin are *D. medinensis*. Since 2005, 30 specimens have been submitted to the CDC, 10 of which were morphologically questionable and sent for DNA typing. Eight were confirmed to be *D. medinensis*, one did not sequence, and one was confirmed to not be *D. medinensis*.

## DISCUSSION

The target to stop transmission of dracunculiasis everywhere by the end of 2009 is now a major challenge, especially for Sudan, Ghana, and Mali. All three countries need to be particularly wary of overconfidence at all levels of their programs and must act on the need to establish adequate surveillance and response to rumors about cases of dracunculiasis in Guinea worm-free areas. In 2007 alone, both Nigeria and Mali were caught off guard by unexpected outbreaks that occurred because of inadequate vigilance in known endemic (Mali) or previously non-endemic (Mali and Nigeria) areas and are suffering the consequences of costly setbacks in reaching zero cases. Other now no longer endemic countries (e.g., Cameroon, Pakistan, Uganda) have experienced similar surprises just as they believed they were on the verge of interrupting transmission.<sup>9,10</sup> Such surprises are not inevitable, but meticulous work is required to prevent them, work which programs ignore at their peril. In the words of one program manager, "You get what you supervise" to which another added trenchantly, "You also get what you don't supervise."

The greatest challenges to the success of the global campaign are sporadic insecurity or widespread civil conflict in Sudan, the uncertainty associated with future political benchmarks in Sudan (census in 2008, national elections in 2009, and referendum on the status of southern Sudan in 2011), and sporadic insecurity in Ghana and Mali, although much less so in Ghana in recent years.

Received June 9, 2008. Accepted for publication June 20, 2008.

**Acknowledgments:** The authors thank Renn McClintic-Doyle, Lauri Hudson-Davis, and Shandal Sullivan for assistance in preparing this manuscript. We also acknowledge the contribution of the national coordinators, village-based volunteers, other health workers in the disease-endemic countries, and other staff of The Carter Center, the WHO Collaborating Center for Research, Training, and Eradication of Dracunculiasis at the CDC, WHO, and UNICEF to these significant accomplishments. We are grateful to Health and Development International for its support of interventions in a number of endemic countries. We publish this paper in memory of Dr. Robert L. Kaiser.

**Financial support:** During 2007–2008, The Carter Center's work to eradicate Guinea worm disease has been made possible by financial and in-kind contributions from BASF Corporation, The Boston Foundation, The Howard G. Buffet Foundation, Canadian International Development Agency, Carani Charitable Foundation, Chevron Corporation, Christian Church Foundation, Inc., The Crawford Family Foundation, Delta Medical Supplies, Early College High School, The Franklin Mint, Bill & Melinda Gates Foundation, Global Aero Logistics, Global Spectrum Inc., Google, Conrad N. Hilton Foundation, John C. and Karyl Kay Hughes Foundation, The John P. Hussman Foundation, Inc., Government of Japan, Johnson & Johnson, The Kendeda Fund, The Kuwait Fund for Arab Economic Development, The AG Leventis Foundation, The John D. and Catherine T. MacArthur Foundation, National Christian Charitable Foundation, Inc., Government of Norway, The Next Generation Fund of the Hugh J.

Andersen Foundation, The Osprey Foundation of Maryland, The P Twenty-One Foundation, Roman Catholic Diocese of Joliet, The Saudi Fund for Development, St. John Student Parish, Thornton Avenue Baptist Church, Trinity Christian College, US Agency for International Development, UNICEF, Vestergaard Frandsen, YKK Corporation, and many generous individuals.

Authors' addresses: Donald R. Hopkins, Health Programs, The Carter Center, 453 Freedom Parkway, Atlanta, GA 30307, Tel: 404-420-3837, Fax: 404-874-5515, E-mail: sdsulli@emory.edu. Ernesto Ruiz-Tiben, Guinea Worm Eradication Program, The Carter Center, 453 Freedom Parkway, Atlanta, GA 30307, Tel: 770-488-4509, Fax: 770-488-4532, E-mail: exr1@cdc.gov. Philip Downs, Guinea Worm Eradication Program, The Carter Center, 453 Freedom Parkway, Atlanta, GA 30307, Tel: 770-488-4507, Fax: 770-488-4532, E-mail: pid9@cdc.gov. P. Craig Withers, Jr., Program Support Health Programs, The Carter Center, 453 Freedom Parkway, Atlanta, GA 30307, Tel: 404-420-3851, Fax: 404-874-5515, E-mail: cwither@emory.edu. Sharon Roy, Division of Parasitic Diseases National Center for Zoonotic, Vector-Borne, and Enteric Diseases Centers for Disease Control and Prevention, MS F22, 4770 Buford Highway NE, Atlanta, GA 30341, Tel: 770-488-4412, Fax: 770-488-7760, E-mail: str2@cdc.gov.

Reprint requests: Donald R. Hopkins, The Carter Center, 453 Freedom Parkway, Atlanta, GA 30307.

#### REFERENCES

1. Hopkins DR, Ruiz-Tiben E, Downs P, Withers PC Jr, Maguire JH, 2005. Dracunculiasis eradication: the final inch. *Am J Trop Med Hyg* 73: 669–675.
2. Hopkins DR, Ruiz-Tiben E, 1991. Strategies for eradication of dracunculiasis. *Bull World Health Organ* 69: 533–540.
3. World Health Organization, 2004. Dracunculiasis eradication: Geneva declaration on guinea-worm eradication, Geneva, 2004. *Wkly Epidemiol Rec* 79: 234–235.
4. World Health Organization, 2008. Dracunculiasis eradication: global surveillance summary, 2007. *Wkly Epidemiol Rec* 83: 159–167.
5. World Health Organization, 2006. Dracunculiasis eradication: ministerial meeting, Geneva, 25 May 2006. *Wkly Epidemiol Rec* 81: 239–240.
6. World Health Organization, 2007. Dracunculiasis eradication: ministerial meeting, Geneva, 16 May 2007. *Wkly Epidemiol Rec* 82: 236–237.
7. World Health Organization, 2007. Dracunculiasis eradication: certification of interruption of transmission. *Wkly Epidemiol Rec* 82: 161–163.
8. Bimi L, Freeman AR, Eberhard ML, Ruiz-Tiben E, Pieniazek NJ, 2005. Differentiating *Dracunculus medinensis* from *D. insignis*, by the sequence analysis of the 18S rRNA gene. *Ann. Trop. Med. & Parasit* 99: 511–517.
9. Hopkins DR, Azam M, Ruiz-Tiben E, Kappus KD, 1995. Eradication of dracunculiasis from Pakistan. *Lancet* 346: 621–624.
10. Rwakimari JB, Hopkins DR, Ruiz-Tiben E, 2006. Uganda's successful Guinea worm eradication program. *Am J Trop Med Hyg* 75: 3–8.