Institution: University of Greenwich

Unit of Assessment: 6 - Agriculture, Veterinary and Food Science

Title of case study: Improving agricultural production on Bioko island, Equatorial Guinea, by elimination of vectors of onchocerciasis (river blindness)

Period when the underpinning research was undertaken: January 2000 – September 2009

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Professor Robert A. Cheke	Professor of Tropical Zoology	01/05/1996 – present

Period when the claimed impact occurred: August 2013 – July 2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact

Onchocerciasis, caused by a nematode worm, leads to morbidity ranging from skin disease to bilateral blindness in 37,000,000 people globally, with rural communities the most at risk. In the island of Bioko, Equatorial Guinea, infection control measures with a drug were not succeeding until research by **Prof. Cheke**, University of Greenwich, underpinned the design and implementation by WHO of an insecticidal control campaign to eliminate the disease's insect vector. This resulted in health, economic and agricultural productivity benefits such as the gross value added to the economy by agriculture increasing from 1.9% in 2015 to 2.3% in 2020 and **350,000 people were free of onchocerciasis by 2017.**

2. Underpinning research

Onchocerciasis, caused by the nematode worm *Onchocerca volvulus* and transmitted by blackflies (*Simulium* spp.), affects millions of people globally. Since 1979 **Professor R. A. Cheke** (Pest Behaviour Group, Natural Resources Institute, which joined University of Greenwich in May 1996) has conducted research on the taxonomy, behaviour, ecology, vector status and control of blackflies in West Africa and elsewhere. Initially, he researched entomological problems encountered by the WHO Onchocerciasis Control Programme in West Africa (OCP; terminated in 2002, but continued with Special Intervention Zones until 2007), involving studies on different members of the *Simulium damnosum* complex (the vectors in most of sub-Saharan Africa). Thus, **Cheke** had the necessary experience to conduct **research that underpinned the elimination of onchocerciasis vectors from Bioko island in 2005** [**3.6**], as part of an international team coordinated by the WHO African Programme for Onchocerciasis Control (APOC), an organisation formed to deal with onchocerciasis in countries that were not participants in the OCP. APOC produced a film about the Bioko elimination and a similar event in Uganda (https://www.youtube.com/watch?v=ba-OKhQQ9k8).

APOC sponsored visits to the island by **Cheke**, M.D. Wilson (project leader, University of Ghana) and collaborators including B. Tele (OCP, insecticide susceptibility tests), R. Meyer (ex OCP, Hamburg, Germany, insecticide applications) and R. J. Post (Natural History Museum, cytotaxonomy), to work in liaison with A. Sima of Equatorial Guinea's Ministry of Health and Social Welfare. **Cheke** was responsible for vector surveys and onchocerciasis transmission estimates. Meyer and Cheke designed the control scheme by mapping and marking field sites targeted for control. They conducted insecticide trials, following susceptibility tests by Tele, using only ground-based applications. Concurrently, they devised a programme for monitoring fly numbers and infection rates that was fully operational in 2001.

After the success of the ground-based control trials, the results were reported to APOC in March 2001 and an APOC meeting held in May 2002 recommended a vector control programme. APOC then instigated helicopter-based control combined with ground treatments in 2003. This attempt was unsuccessful because some vector breeding sites in irrigation channels were not treated, despite their locations having been reported by **Cheke** in 2001. Nevertheless, **a second control programme in 2005 succeeded in eliminating the vectors.**

Examples of Cheke's research that underpinned the impact by contributing directly to the success of the control campaign were: (i) confirmation that only one vector taxon was present [**3.4**]; (ii) description of this vector as a new form [**3.5**]; (iii) estimates of its vectorial efficiency [**3.3**]; (iv) delimitation of its geographic distribution for selection of insecticide treatment sites, in a vector elimination plan proposing targeting the vector's more restricted range during dry seasons [**3.2**], after (v) trials of insecticides, testing the feasibility of such controls with ground-based trials, and ascertaining that elimination would be impossible without aerial control support due to areas of rugged terrain [**3.2**].

The anti-vectorial campaign was conducted in conjunction with mass drug administration (MDA) of ivermectin. *O. volvulus* worms reproduce by releasing offspring (microfilariae), which cause the pathology and are ingested by the vectors. Although these microfilariae can be killed by the drug ivermectin, there was no registered macrofilaricide that could kill the adult worms which live for up to 12 years. As there are contra-indications for chemotherapy with ivermectin in onchocerciasis patients co-infected with the eye-worm *Loa loa*, it was instructive that proven vectors of *L. loa* were identified on Bioko by **Cheke** during his field work on onchocerciasis [**3.1**]. This was a timely warning as autochthonous transmission of the disease was demonstrated in 2017 by Priest & Nutman and later confirmed in 2018 by Ta et al.

3. References to the research

1. **Cheke, R. A**., Mas, J. & Chainey, J. E. (2003) Potential vectors of loiasis and other tabanids on the island of Bioko, Equatorial Guinea. *Medical & Veterinary Entomology* 17: 221-223. https://doi.org/10.1046/j.1365-2915.2003.00436.x

2. **Cheke, R. A**., Meyer, R.R.F., Barro, T., Mas, J., Sima, A. N., Abaga S. E., Noma, M., Sékételi, A.V. & Wilson, M. D. (2009) Towards the elimination of the Bioko form of *Simulium yahense* from Bioko: planning and insecticide trials. *Acta Zoologica Lituanica* 19: 132-141. https://doi.org/10.2478/v10043-009-0013-8 (available at https://bit.ly/3s0vasB)

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4. Mustapha, M., McCall, P. J., **Cheke, R. A.** & Post, R. J. (2006) The blackflies (Diptera: Simuliidae) of Bioko (Republic of Equatorial Guinea) and the Gulf of Guinea with a description of the larvae of the 'Pomeroy' form of *Simulium cervicornutum*. *Systematic Entomology* 31: 611-620. https://doi.org/10.1111/j.1365-3113.2006.00330.x

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6. Traoré, S., Wilson, M. D., Sima, A., Barro, T., Diallo, A., Aké, A., Coulibaly, S., **Cheke, R. A.,** Meyer, R., Mas, J., McCall, P. J., Post, R. J., Zouré, H., Noma, M., Yameogo, L., Sékétéli,

A. V. & Amazigo, U. V. (2009) The elimination of the onchocerciasis vector from the island of Bioko as a result of larviciding by the WHO African Programme for Onchocerciasis Control. *Acta Tropica* 111: 211–218. https://doi.org/10.1016/j.actatropica.2009.03.007

Key grants

Project Title "Onchocerciasis vector elimination project, Bioko, Republic of Equatorial Guinea". WHO/World Bank African Programme for Onchocerciasis Control. Awarded to National Onchocerciasis Task Force Bioko, Ministry of Health and Welfare, Equatorial Guinea. External scientists' team, including **R.A. Cheke**, led by Dr M. D. Wilson of Parasitology Unit, Noguchi Memorial Institute for Medical Research, University of Ghana, Legon, Accra, Ghana. Duration March 1999 – February 2002. Value: US$334,744 (£257,082).

4. Details of the impact

The existence of onchocerciasis on the island of Bioko and its detrimental effects on the health, well-being and socio-economic development of the island's population required interventions. As a mass drug administration programme was not succeeding, research was conducted by a UoG researcher aimed at achieving control by elimination of the disease's insect vector. **Elimination of onchocerciasis transmission on the island of Bioko, Equatorial Guinea, in 2005 has now protected more than 350,000 people, especially since 2017 when the last adult worms within patients died**. Freedom from onchocerciasis allowed communities to increase agricultural production to improve their livelihoods, with consequent benefits to health, agricultural productivity and the country's economy.

UoG research enabled the island of Bioko to be free of onchocerciasis vectors. The impacts of the research not only had immediate effects after the successful control of the disease in 2005 but they also had accruing beneficial effects on human health and well-being, household income and agricultural productivity from then onwards. However, this could only be indisputably confirmed in 2017 due to the long-term nature of the infection. The adult worms responsible for the disease can live for up to 12 years, so those infected before the control campaign would retain morbidity until either they or the worms died. Therefore, the success of the vector elimination programme in 2005 could only be demonstrated unequivocally a minimum of 12 years after the intervention, i.e. by 2017 within the eligible impact period.

A study conducted in January and February 2014 found that 22% of 150 households in Bioko had at least one positive case of onchocerciasis [**5.1, page 1022**], whilst another study only detected one positive case in a sample of 543 people [**5.6, page 14**]. Further studies, also conducted in 2014, showed an overall seroprevalence of 7.9%, but, significantly, only in samples of individuals 10-years-old or older [**5.3**, **page 1**; **5.5, page 1**]. This evidence showed that the vector control of 2005 had led to a permanent cessation of transmission. This conclusion was reinforced by a study in 2016-2017 that found no evidence of current infection or recent transmission and no evidence of onchocerciasis vectors, concluding that WHO serologic criteria for the cessation of MDA had been met [**5.4, page 2**]. At the time of these studies, the population of Bioko who had benefitted from the interventions since 2005 had reached 334,463 and the resulting health and well-being benefits would, amongst other improvements, have translated into an increase in productivity of agricultural workers.

Research by UoG resulted in agricultural economic growth in Bioko. Given that apart from detriments to life quality, onchocerciasis-infected farmers weed 34% less of fields than healthy farmers, the elimination of the vector in Bioko will have had similar economic and health impacts to those in the OCP area but on a proportionally smaller scale. In the OCP's 11 West African countries economic benefits accruing from onchocerciasis control exceeded US$500,000,000, saving 640,000 disability adjusted life years (DALYs) per annum and adding 15,000,000 hectares of new land available for agriculture, benefits that were reviewed in 2019 [**5.7**]. Although disaggregated data separating Bioko from mainland Equatorial Guinea (Rio Muni) are unavailable, an indicator of impact relevant to Bioko since the vector elimination is the overall percentage of

gross value added to the economy by agriculture, which had been 1.1% in 2010, increased from 1.9% in 2015 to 2.3% in 2020 (http://data.un.org/en/iso/gq.html). Regarding crops grown on the island, data for Equatorial Guinea [**5.2**] show that gross values increased after 2005 and during the impact period after 2013 (Table 1). These data refer to Equatorial Guinea as a whole and include the mainland where onchocerciasis remains prevalent and where no onchocerciasis vector control took place (only MDA control), so the benefits on Bioko were probably higher than the reported numbers suggest.

Table. 1 Gross Production Values (constant 2014-2016 million US$) for Equatorial Guinea of crops grown on Bioko, including some requiring labour-intensive farming.

Crop	Year			% increase 2005-2018	% increase 2013-2018
	2005	2013	2018		
Bananas	12.37	14.61	15.94	28.9	9.1
Cassava	17.31	21.52	23.95	38.4	11.3
Coconuts	2.54	2.95	3.02	18.9	2.4
Plantains	12.86	14.53	15.50	20.5	6.7
Sweet potatoes	21.70	32.42	38.03	75.2	7.3

Another country adopts a strategy to control onchocerciasis developed by UoG researcher. The demonstration that successful onchocerciasis control can be achieved by vector control in a delimited area such as Bioko has influenced strategies to control the disease elsewhere. For instance, the example of the control in Bioko [**3.6**] influenced advocacy for an insecticidal campaign along the Sanaga River in the Littoral Province and elsewhere in Cameroon [**5.8, page 2; 5.10**] and was used [**5.9, ref. 18 on page 2; 5.11**] to underpin a plan published in 2019 for a DFID-sponsored programme combining MDA using a novel macrofilarial drug (doxycycline) with vector control, also in Cameroon. This plan is being implemented in the South West Province of Cameroon, an area with loiasis co-endemicity, where MDA with ivermectin has been proceeding for 12 years yet onchocerciasis persists with a higher than expected prevalence and intensity. (https://countdown.lstmed.ac.uk/sites/default/files/centre/CS.%202.%20Implementing%20Alternative%20Strategies%20for%20Oncho%20Control.pdf). The Non-Governmental Organization Sightsavers stated that the "demonstration that river blindness control can be achieved through focal vector elimination has had impact wider than just Bioko, as it has informed strategies to combat river blindness elsewhere" [**5.11, page 2**] and regarding control on the Sanaga River the Yaoundé Initiative Foundation stated that "The lasting impact of this success is reflected by the continuation of this vector control programme in Cameroon over a limited length of the Sanaga river, thereby protecting farmers and allowing them to increase their productivity" [**5.10, page 2**].

5. Sources to corroborate the impact

1. Barroso, D.G., Moya, L., Herrador, Z. *et al.* (2018) Spatial clustering of onchocerciasis in Bioko Island, Equatorial Guinea. *The Journal of Infection in Developing Countries* 12: 1019-1025. https://doi.org/10.3855/jidc.10159

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5. Moya, L., Herrador, Z., Ta-Tang, T.H. *et al*. (2016) Evidence for suppression of onchocerciasis transmission in Bioko Island, Equatorial Guinea. *PLoS Neglected Tropical Diseases* (2016) 10: e0004829. https://journals.plos.org/plosntds/article?id=10.1371/journal.pntd.0004829

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7. Turner, H.C., Walker, M., Pion, S.D.S. *et al.* (2019) Economic evaluations of onchocerciasis interventions: a systematic review and research needs. *Tropical Medicine & International Health* 24:788-816. https://doi.org/10.1016/j.actatropica.2017.12.030

8. Che, J.N., Baleguel, P.N., Baleguel, P.D. *et al.* (2017) River blindness – A neglected disease transmitted by blackflies (*Simulium* spp.). *Outlooks on Pest Management* August 2017: 1-4. https://international-pest-control.com/river-blindness-neglected-disease-transmitted-blackflies-simulium-spp

9. Wanji, S., Nj, T.M., Hamill, L. *et al.* (2019) Implementation of test-and-treat with doxycycline and temephos ground larviciding as alternative strategies for accelerating onchocerciasis elimination in an area of loiasis co-endemicity: the COUNTDOWN consortium multi-disciplinary study protocol. *Parasites & Vectors* (2019) 12: 574. https://doi.org/10.1186/s13071-019-3826-8

10. Testimonial, Feb 2021 - Prof Graham Matthews, Technical Director, Yaounde Initiative Foundation (Cameroon, UK). G.A. (2021)

11. Testimonial, Feb 2021 – Dr Louise Hamill, Global Technical Lead, Onchocerciasis and LF Sightsavers (UK)