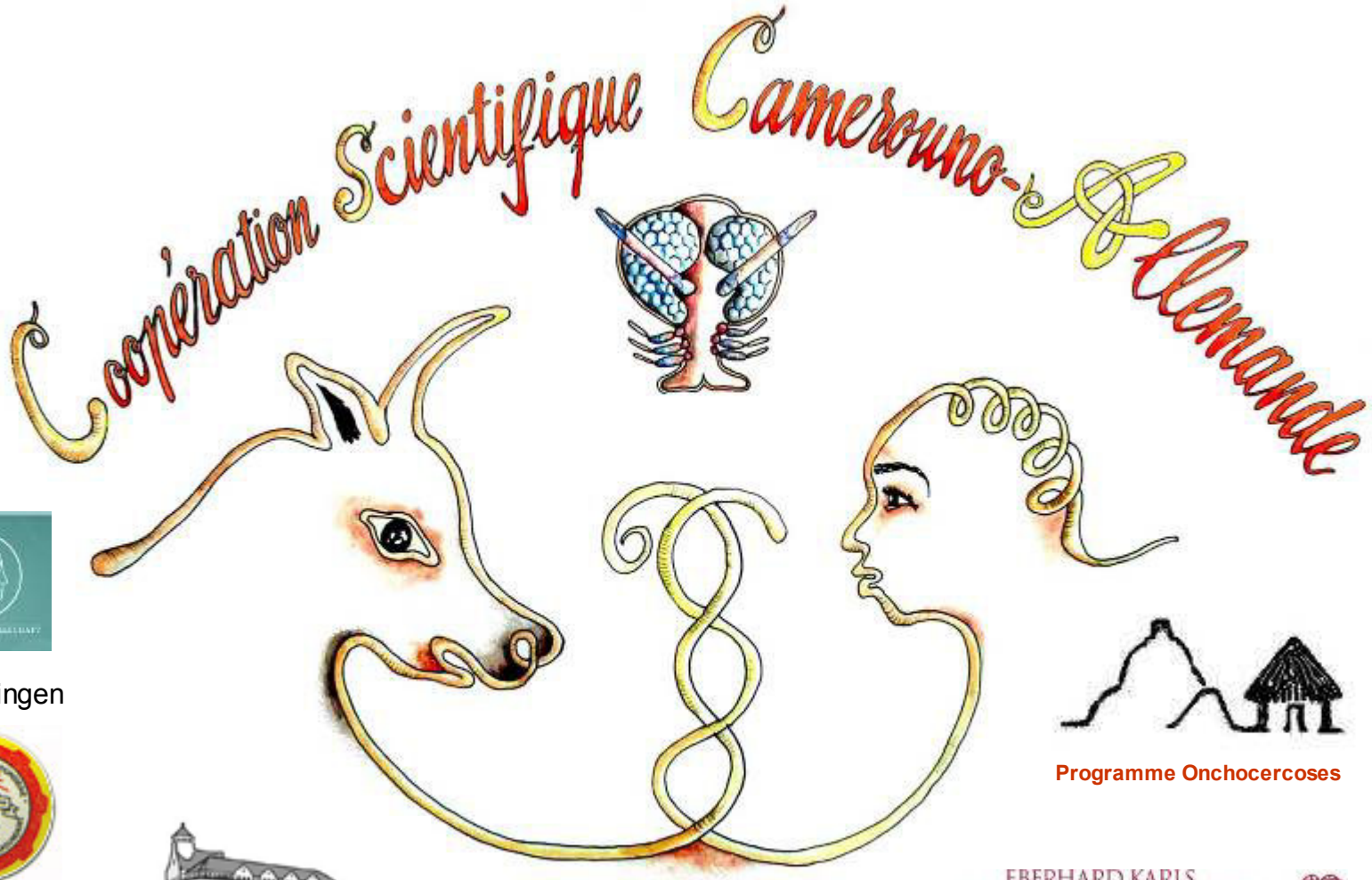
Can Onchocerciasis Be Eradicated ?
Epidemiological, biological and molecular genetic studies in a bovine model in North Cameroon



MPI Tübingen

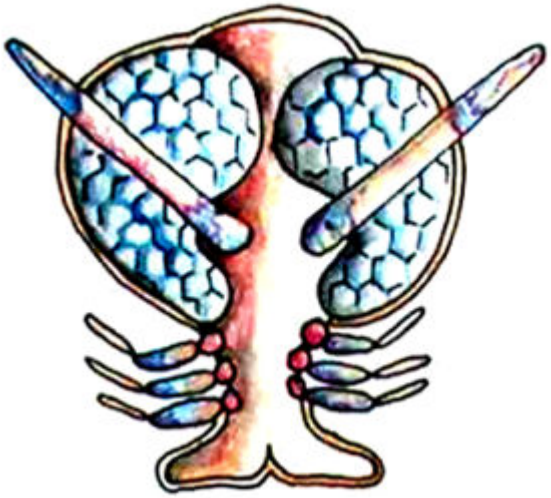
Universities of Bamenda and Ngaoundéré

BERNHARD-NOCHT-INSTITUT FÜR TROPENMEDIZIN

Programme Onchocercoses

EBERHARD KARLS UNIVERSITÄT TÜBINGEN

IRAD



Issek

Cameroonian painter,

"Painter of the year 2005"

Paralysed legs from polio

When designing our logo of the two worms of man and cattle (according to a draft of A. Renz), he particularly insisted on the six legs of the *Simulium* fly: It is the high motility of these vectors, that delimits the distribution of onchocerciasis.

Simulium damnosum s.l.

Photo from WHO, internet

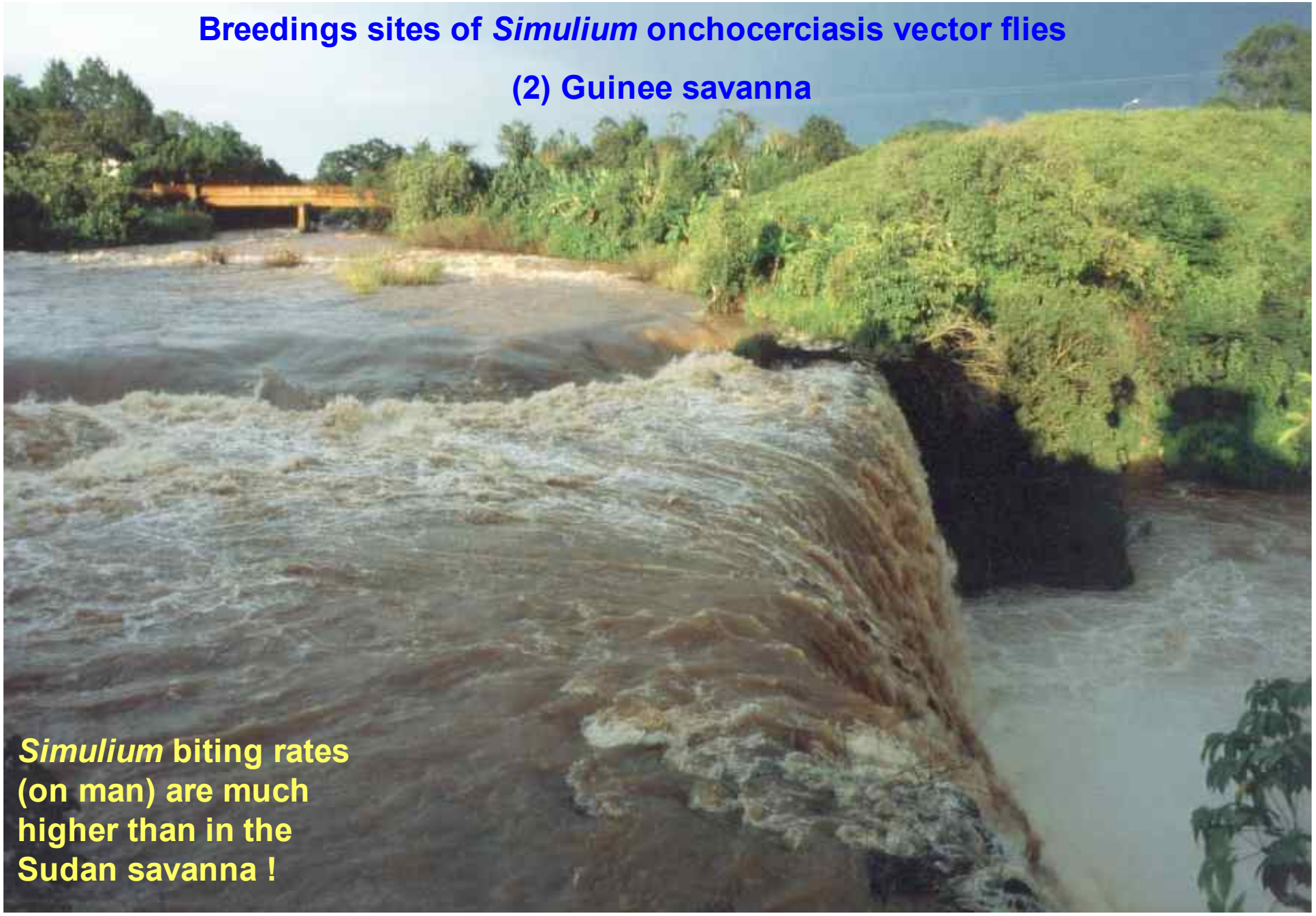
Breedings sites of *Simulium* onchocerciasis vector flies

(1) Sudan savanna

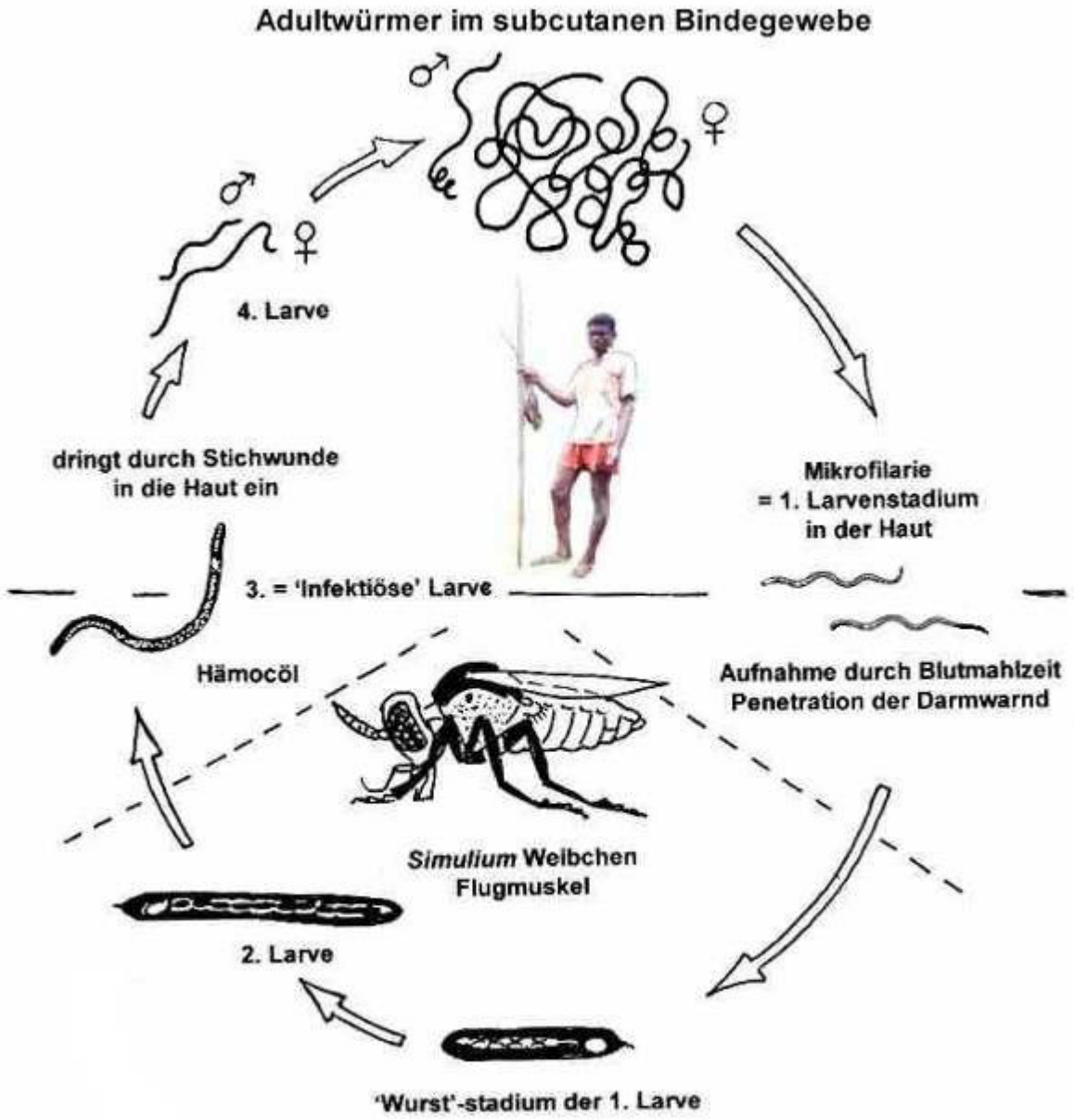
Campement du Syrien, Vina du Nord. Touboro => **Hyperendemic ! Blindness!**

Breedings sites of *Simulium* onchocerciasis vector flies

(2) Guinee savanna



Vina du Sud, Guinea-Savanna, Galim: **hypoendemic, no blindness => why?**



Zyklus Onchocerca volvulus (Onchozerkose) in Afrika

Onchocerciasis

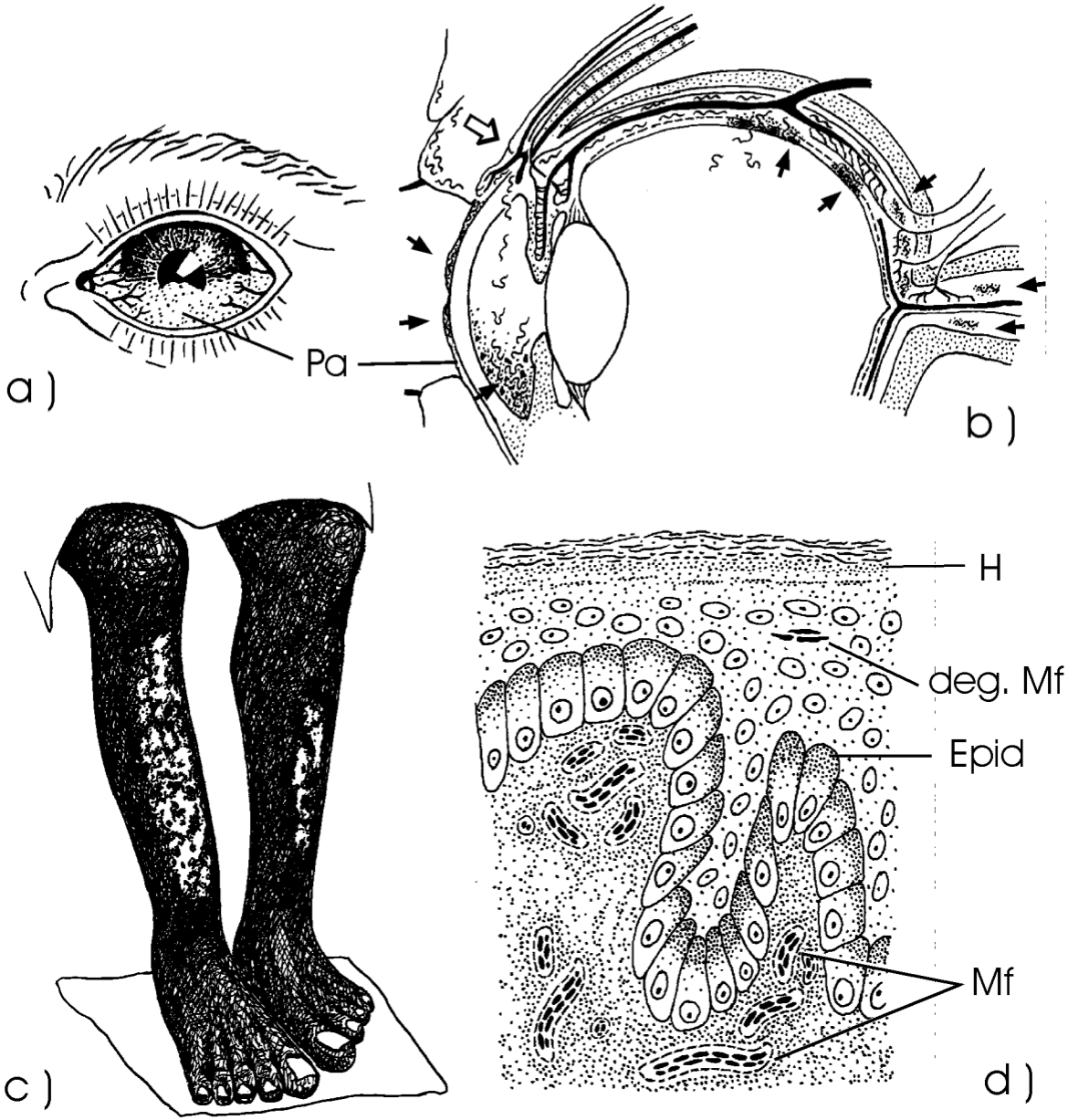
Ca. 17 million people affected

Most frequent cause of blindness in the African savanna

Control

- **OCP : Vector control**
- **APOC: Ivermectin**

- **No macrofilaricide**
- **No vaccination**



Wenk & RENZ, Biologie d. Humanparasiten, 2003

Pathologie:

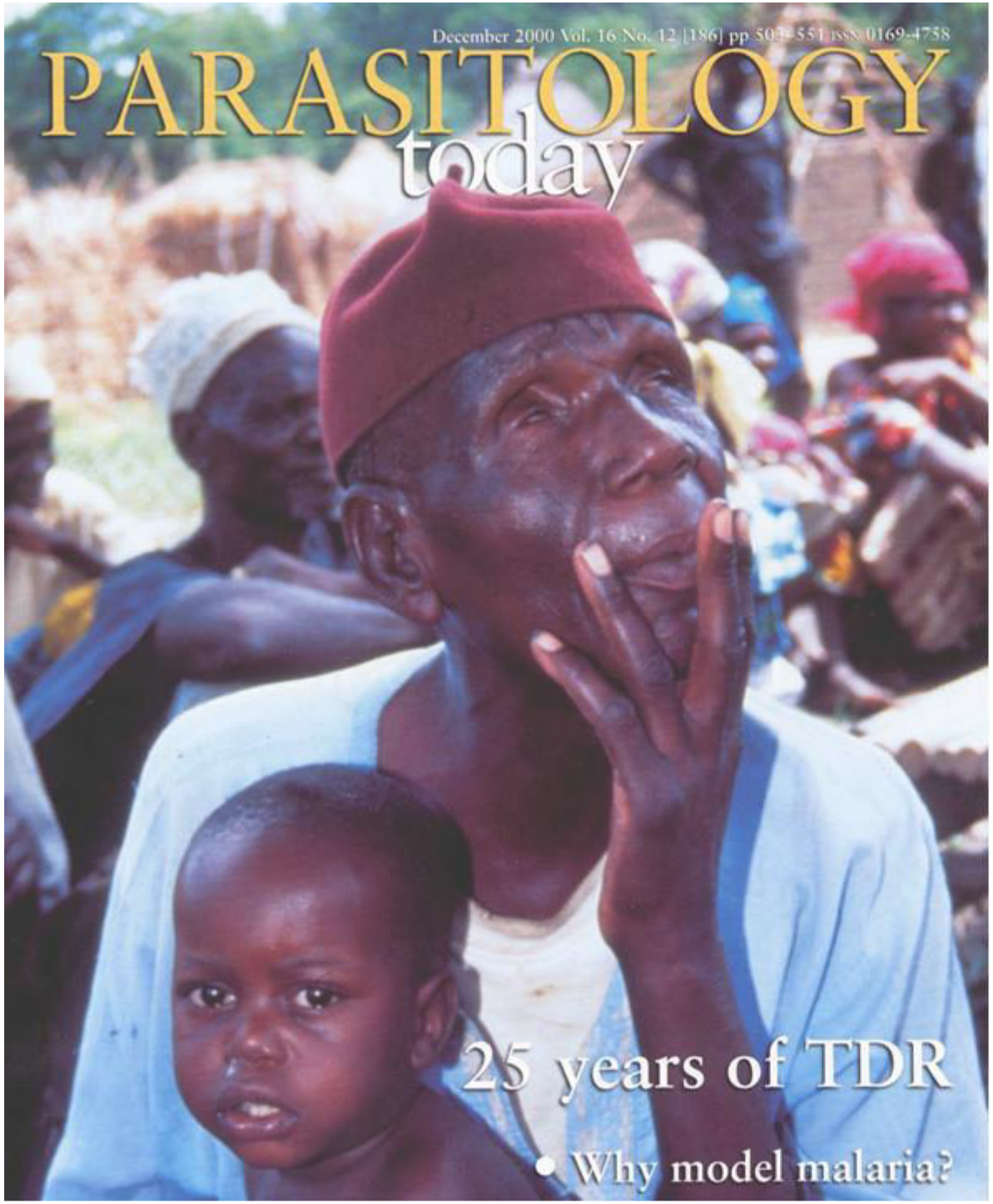
Die 0,3 mm langen Mikrofilarien bevölkern die Haut (bis > 100/mm2) und zerstören diese langsam.

Im Auge bilden sich erst lokale, dann generalisierte Entzündungen: Keratitis, Iritis, Chorioretinitis und Atrophie des optischen Nervs

Die Erblindung trifft oft schon Jugendliche.

Im Alter leiden viele Männer an Augenschädigungen.

In der Savanne erblinden mehr Menschen als im Regenwald.



Results from Tchollire:

Criteria for successful control of onchocerciasis in West-Africa

ATP 100

ABR 1000

Mathematical model (Klaus Dietz)

Results 1976 – 1979

=> Blindness occurs at sites with very high transmission potentials (> 1000)

Nana Hamadou, Fly-collector since 1984

The typical patient infected with onchocerciasis does not become blind and is nowadays protected by Ivermectin

Einer Geißel der Menschheit wird zu Leibe gerückt

Die Tage der Flußblindheit sind gezählt

Neues Medikament bringt Hoffnung für Millionen Menschen in Afrika und Lateinamerika

Von unserem Redaktionsmitglied Georges Stavrakis

In unseren Breitengraden ist sie völlig unbekannt. In großen Teilen der Dritten Welt löscht sie ganze Dorfgemeinschaften aus: die Onchozerkose, auch Flußblindheit genannt. Statistiken der Weltgesundheitsorganisation (WHO) zufolge, sind weit über 50 Millionen Menschen in Afrika und Teilen Südamerikas von der vernichtenden Krankheit bedroht, die von der schwarzen Fliege übertragen wird. Allein in West- und Zentralafrika, so schätzt die WHO, leiden zur Zeit mehr als 17 Millionen Menschen an Onchozerkose – Tendenz steigend. Nun endlich ist Hilfe in Sicht. Ein neu entwickeltes Medikament in Tablettenform kann unzähligen von Blindheit und Tod bedrohten Menschen Gesundheit und Leben retten.

„Mectizan" heißt das Mittel, mit dem die WHO und viele nichtstaatliche Organisationen massiv gegen die Flußblindheit vorgehen wollen. Eine dieser Organisationen ist die südhessische Christoffel-Blindenmission (CBM).

„Das ist endlich der Durchbruch. Nach mehrjähriger Testphase ist das Medikament endlich einsetzbar", sagt Wolfgang Jochum von der CBM. Dr. Daniel Ety'Ale aus Kamerun, den die CBM nach Bensheim eingeladen hatte, um über die Erfolge von Mectizan zu berichten, gerät geradezu ins Schwärmen: „Mit diesem neuen Medikament ist ein entscheidender Schritt im Kampf gegen die Flußblindheit gelungen."

Der afrikanische Arzt kämpft sozusagen an vorderster Front gegen die heimtückische Krankheit. „Wegen der Flußblindheit müssen in vielen Gebieten ganze Dörfer in Flußnähe aufgegeben werden", berichtet er. Da das Leiden den ganzen Organismus befällt, ist die Sterblichkeit der von Onchozerkose betroffenen Bevölkerungsschichten dreimal so hoch wie die der Normalpopulation.

Vor der schwarzen Fliege, die die Krankheit überträgt, konnte sich bislang keiner schützen. Kinder, die im Wasser spielen, Frauen, die am Fluß waschen und Wasser holen, Fischer, die vom Fluß leben, sie alle wurden Opfer des kleinen schwarzen Insekts. Der wichtige Lebensraum Fluß – für Menschen in der Dritten Welt Treffpunkt, Nahrungsmittellieferant oder Transportweg – war und ist ein Ort der Bedrohung.

Bereits 1974 begann die WHO zusammen mit den Vereinten Nationen das „Onchozerkose-Kontrollprogramm" in Westafrika. Damals wurden die Flüsse mit Insektiziden besprüht, um der schwarzen Fliege den Garaus zu machen. Diese Maßnahme war sehr erfolgreich, erreichte freilich nicht die Menschen, die außerhalb des Aktionsgebietes lebten.

Mit dem neuen Medikament ist nun eine großflächige Bekämpfung der Krankheit möglich. Leider kommt die Hilfe für rund 600 000 Menschen entlang der Flüsse West- und Zentralafrikas zu spät. Sie sind bereits unheilbar erblindet. Hunderttausende sind in den vergangenen Jahren aus ihrem angestammten Lebensraum vor der Gefahr geflohen.

Die Flußblindheit stellt mehr als ein verheerendes Gesundheitsproblem dar. Denn die Erblindeten belasten nicht nur ihre Familien, sondern führen ob ihrer großen Zahl zum Stillstand der ökonomischen Entwicklung ganzer Regionen. Diese Tatsache ist deshalb besonders tragisch, als das Leiden durch eine Art Schluckimpfung mit Mectizan vermeidbar ist. Ein erstmal von Onchzerkose Befallener ist dem Leiden dagegen hilflos ausgeliefert.

Der große Vorteil von Mectizan ist, daß ein Mensch nur einmal im Jahr eine Tablette schlucken muß, um vor der Krankheit für eben diesen Zeitraum geschützt zu sein. Die regelmäßige Einnahme soll durch die Einführung eines Impfpasses gewährleistet werden. Das Medikament wird der CBM von der Herstellerfirma Merck, Sharpe und Dohme kostenlos zur Verfügung gestellt, für die Verteilung muß das Missionswerk selbst aufkommen. Bis Ende dieses Jahres sollen rund eine Million Tabletten verteilt werden. „Die große Chance, Menschen vor dem Erblinden zu bewahren,

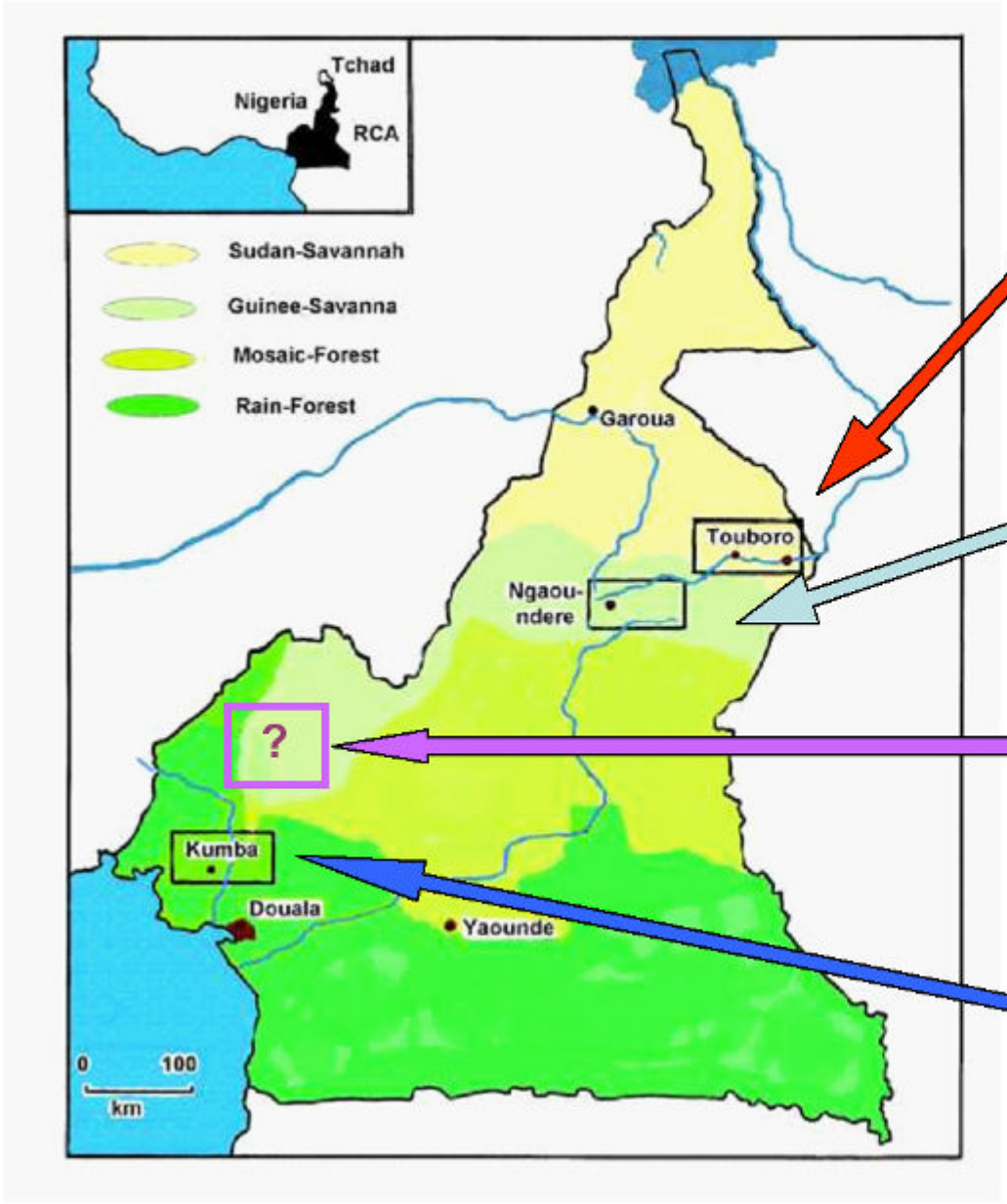
Wie entsteht Flußblindheit?

Flußblindheit ist das Ergebnis einer Infektion, die durch einen Parasiten, einen Wurm, verursacht wird. Befallen werden vor allem Menschen, die in Afrika und Teilen von Lateinamerika in der Nähe von Flüssen leben. Die Infektion zerstört nach und nach das Auge, führt dadurch zu einem Nachlassen des Sehvermögens und letztlich zur Blindheit, die nicht mehr geheilt werden kann.

Die Krankheit wird von einer kleinen, schwarzen Fliege, Simulium, übertragen. Sie legt ihre Eier in Flüssen ab; daher auch wird ein Wurm in den Körper übertragen. Dieser Wurm hat den Namen „onchocerca volvulus" und produziert Millionen mikroskopisch kleiner „Baby-Würmer", die sogenannten Mikrofilarien. Diese befallen den ganzen Körper, besonders die Haut und die Augen, was letztlich zu einem Verlust des Sehvermögens führt. Der korrekte Name der Infektion, die zur Flußblindheit führt, ist „Onchozerkose".

Bei den Infizierten zeigen sich folgende Symptome: Hautjucken, Knoten, rote, wäßrige Augen und langsames Nachlassen der Sehkraft. Ein einfacher Gewebetest reicht aus, um die Infi-

Human onchocerciasis in Cameroon, prevalence before Ivermectin mass-treatments:



Sudan-Savanne (Touboro, M. Galke):

> 90 % Prevalence

- Severe eye-lesions
- Savanna strain of *O. volvulus*

Adamaoua-Plateau (Galim):

< 20 % Prevalence

- No eye-lesions, Oncho-strain yet unknown
- Cattle-zooprophylaxis !!

Mentchum-river valley (not visited):

- high prevalence reported
- skin-lesions reported, strain unknown
- Cattle-zooprophylaxis ???

Rain-Forest (Bombe, Bolo)

- 95 % Prevalence
- frequent skin lesions, little eye-leions
- Rain-forest strain of *O. volvulus*

Data from Renz et al. 1987, Wahl et al. 1997, Anderson & Fuglsang, 1975

Can the fight be won ?

$R_o > 100$

- community-based treatment reaches 60-70 % all villagers
- transmission continues
- high risk of resurgence:

  density-dependent regulation !!

- resistence against ivermectin

- onchocerciasis is likely to disappear from hypo- or mesoendemic areas
- combination of control measures: macrofilaricide, vaccine, zooprophylaxis, reduction of man-fly contact, local vector control

Onchocerca ochengi

Onchocerca volvulus

"The bovine model"

Since 1992

Chemotherapy

immunology

biology

Savannah type of human onchocerciasis

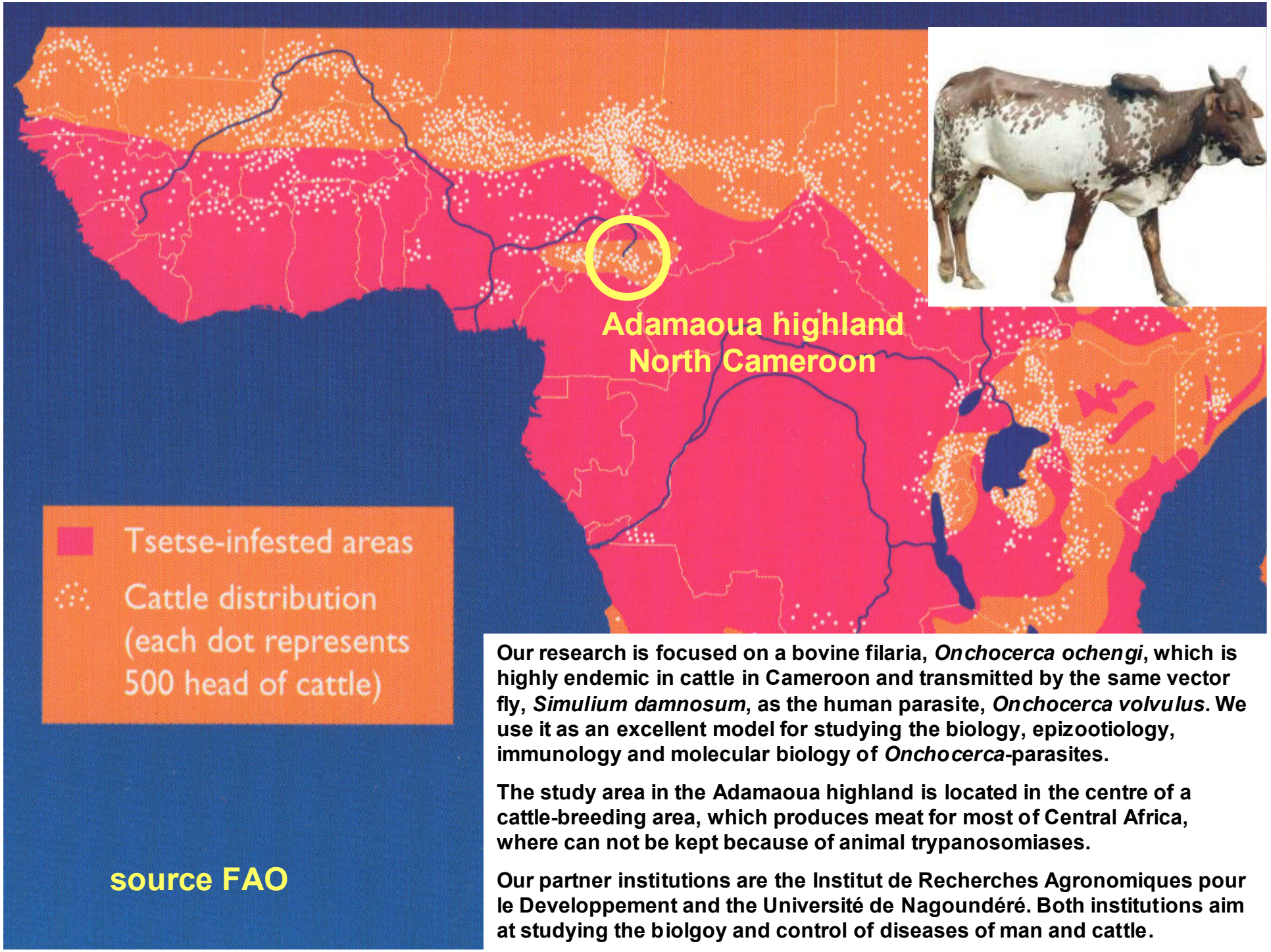
Prevalence > 90 %

⇒ many eye-lesions

⇒ river blindness

⇒ epidemiology since 1976

⇒ ivermectin since 1987



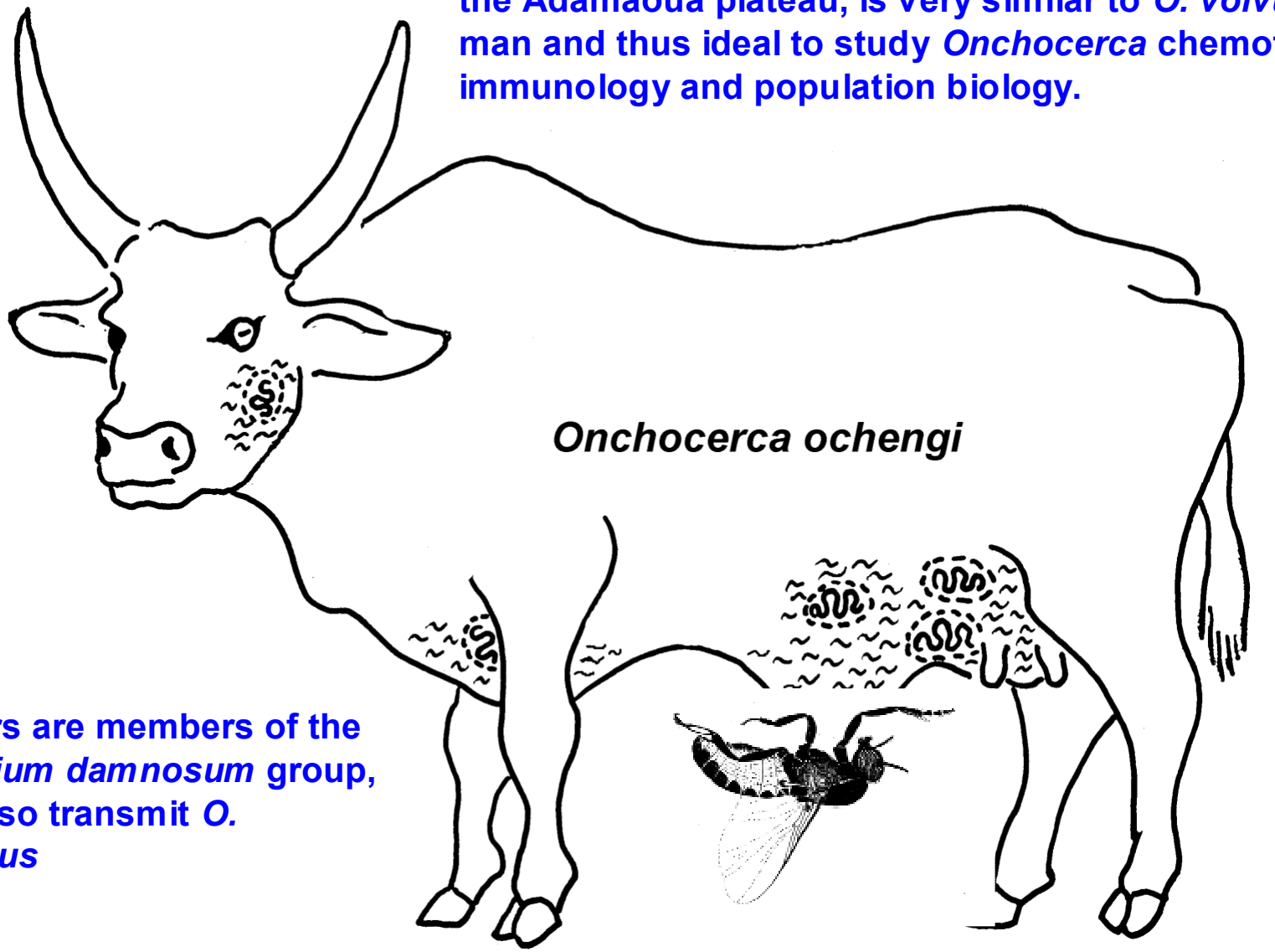
Our research is focused on a bovine filaria, *Onchocerca ochengi*, which is highly endemic in cattle in Cameroon and transmitted by the same vector fly, *Simulium damnosum*, as the human parasite, *Onchocerca volvulus*. We use it as an excellent model for studying the biology, epizootiology, immunology and molecular biology of *Onchocerca*-parasites.

The study area in the Adamaoua highland is located in the centre of a cattle-breeding area, which produces meat for most of Central Africa, where can not be kept because of animal trypanosomiases.

Our partner institutions are the Institut de Recherches Agronomiques pour le Developpement and the Université de Nagoundéré. Both institutions aim at studying the biolgoy and control of diseases of man and cattle.

The bovine *Onchocerca ochengi* model:

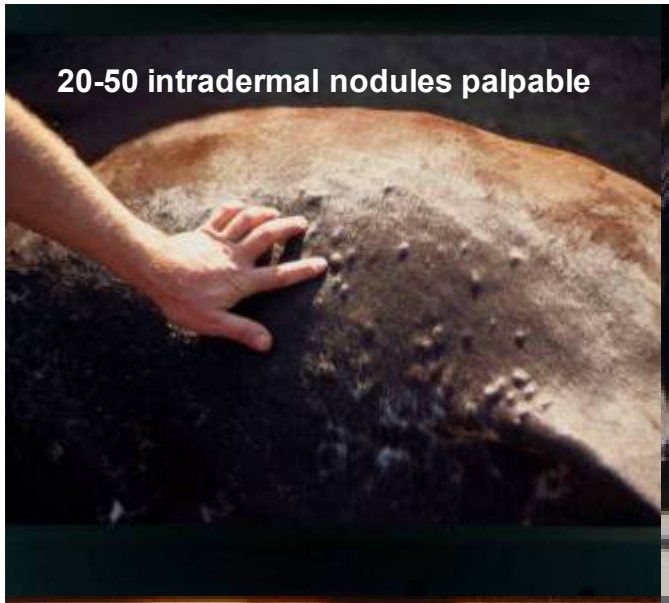
This nodule-forming filaria, which is highly endemic on the Adamaoua plateau, is very similar to *O. volvulus* in man and thus ideal to study *Onchocerca* chemotherapy, immunology and population biology.

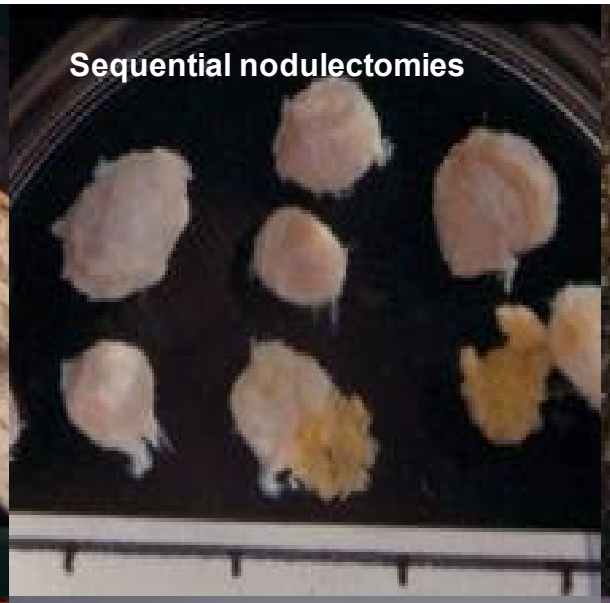


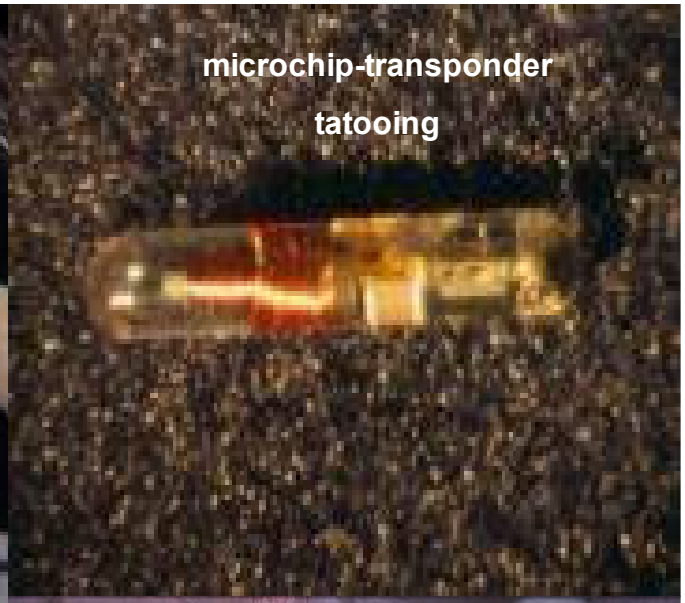
Vectors are members of the *Simulium damnosum* group, that also transmit *O. volvulus*

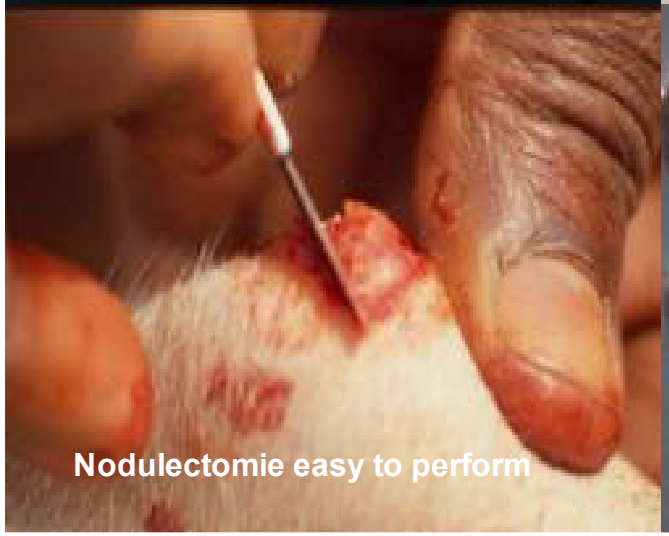
Onchocerca ochengi in African cattle: The bovine onchocercosis model

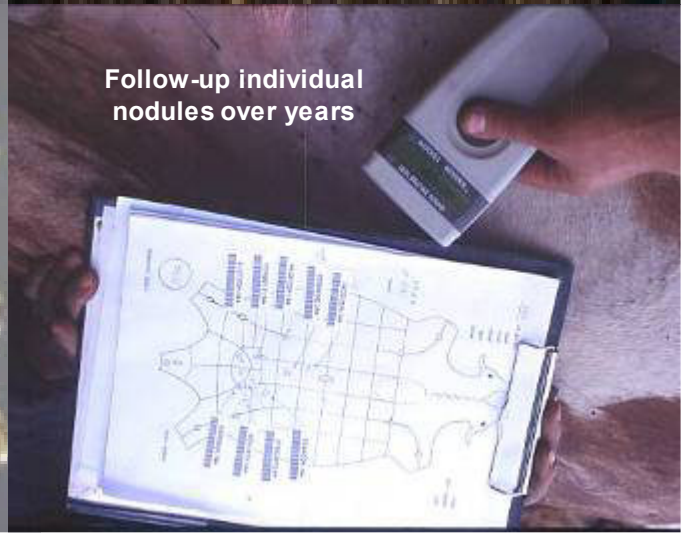
since 1990, A. Renz, D. Achukwi, G. Wahl, S. Trees et al.







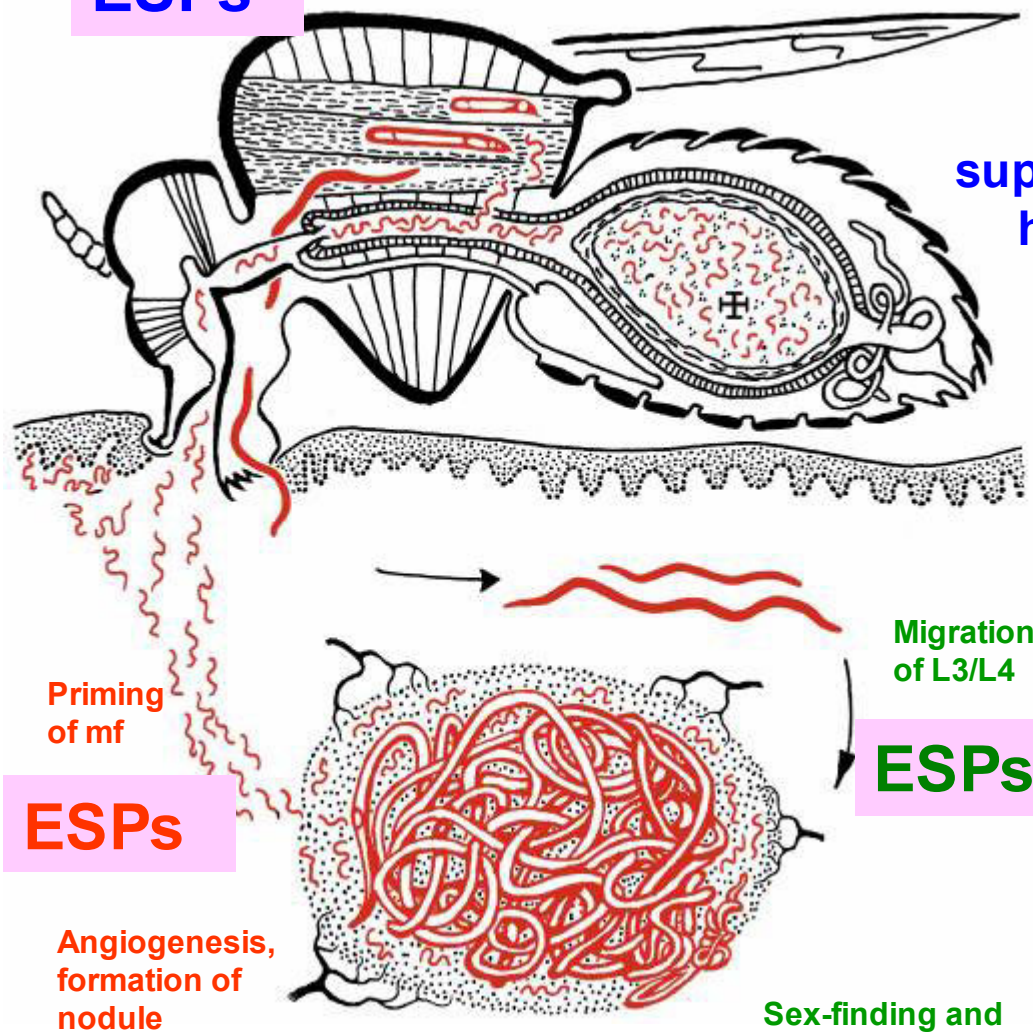




Parasite-host crosstalks

Suppression of Internal Defence System,
Hypertrophy of host-muscle cell,
formation of syncytium

ESPs



Migration
of L3/L4

Priming
of mf

ESPs

ESPs

Angiogenesis,
formation of
nodule

Sex-finding and
mating behaviour

Microfilariae-birth-rate
and control of survival

worm → *Simulium* vector

manipulation of fly-host:
suppression of Internal Defence System
hypertrophy of muscle cell (L1-L3)

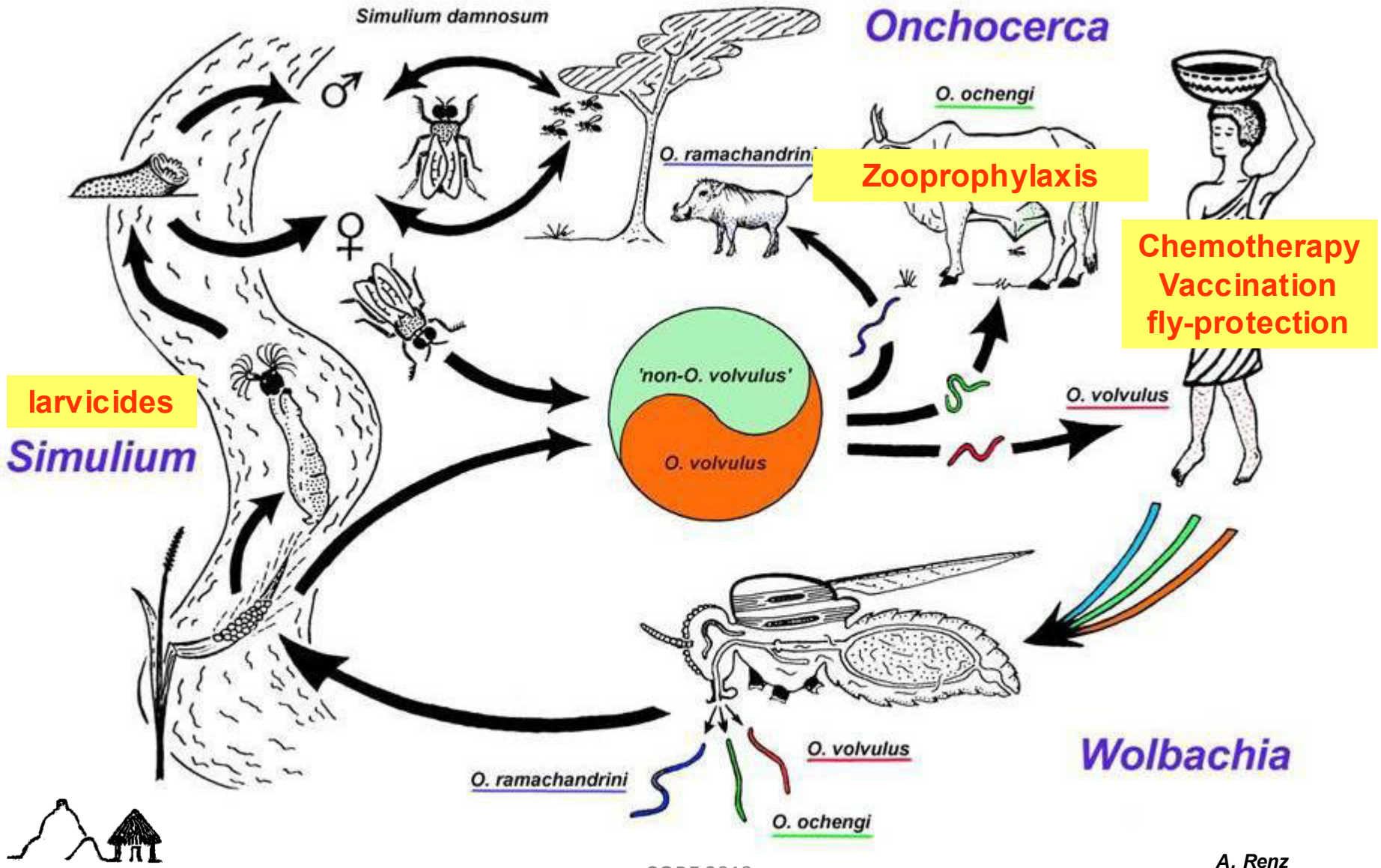
worm → worm

parasite intraspecific communication:
self-regulation by apoptosis
location of nodules and finding of partners,
mating and microfilariae-production

worm → vertebrate host

manipulation of vertebrate host:
induction of nodule-formation
angiogenesis
immune-stimulation and suppression

Simulium – *Onchocerca* Crosstransmission



A. Renz

Identification of Exretory-Secretory-Products (ESPs) from adult worms => Hamburg

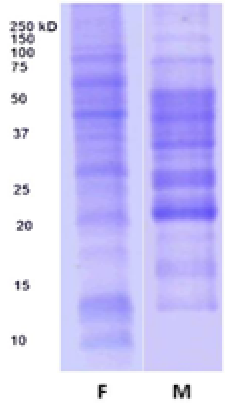
- ✓ 156 gels reveal sex-specific ESP-pattern
- ✓ so far, 10 lanes were analysed by LC-MS/MS
- ✓ identification of > 400 proteins
- ✓ enzymatic antioxidants, surface associated and known immunodominant proteins

Proteins identified in the ES-products from female or male *O. ochengi*

	Female	Male
Signal peptide-carrrying E/S proteins of nematode homologues	Cystatin Ov87 Glutathione S-transferase 3 FAD-dependt oxidoreductase HSP 3 Microfilaria surface-associated p. Transmembrane p. Immunodominant Ag CAA31 Ov16 Ag, Phosph.-ethanolamine dp Wolbachia surface p. (WSP) W-HSP 60	Cystatin Ov87 Immundominant hypodermal Ag HSP 70 Putative nuclear encoded p AAD1979, P22U
Homologues of described nematode E/S proteins w/o signal peptide	Glutathione reductase Glutathione S-transferase Thioredoxin peroxidase 1 Peroxidoxin-2 Oxidoreductase 75 kDa Thiol-specific anti-oxidant Immunodominant Ag Ov33 HSP 60, HSP 90	Thiol-specific anti-oxidant Galectin-1 (D.i.) Immunodominant Ag Ov33 15 kDa ladder Ag HSP 60, HSP 70, HSP 90
Homologues of not described nematode E/S proteins	Ig I-set domain containing p. 14-3-3-like protein 2 OvT1 major antigen	Coronin-like p. Ig I-set domain containing p. Calponin homolog Ov9M

MS/MS sequencing of 10 lanes

Differences in the protein bands of E/S products from female *vs.* male *O. ochengi*



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N. Brattig
K. Manchang

BERNHARD-NOCHT-INSTITUT
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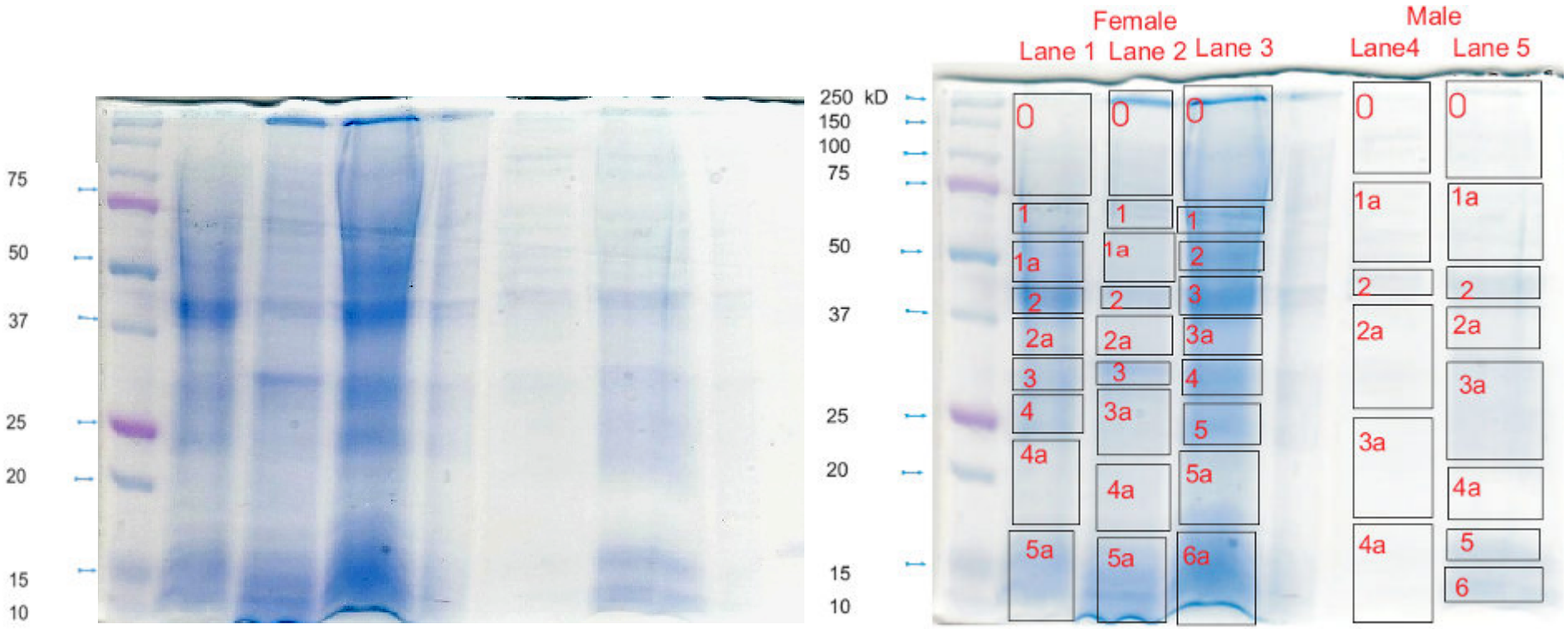
Sequencing gel of ESPs from female and male *Onchocerca ochengi*



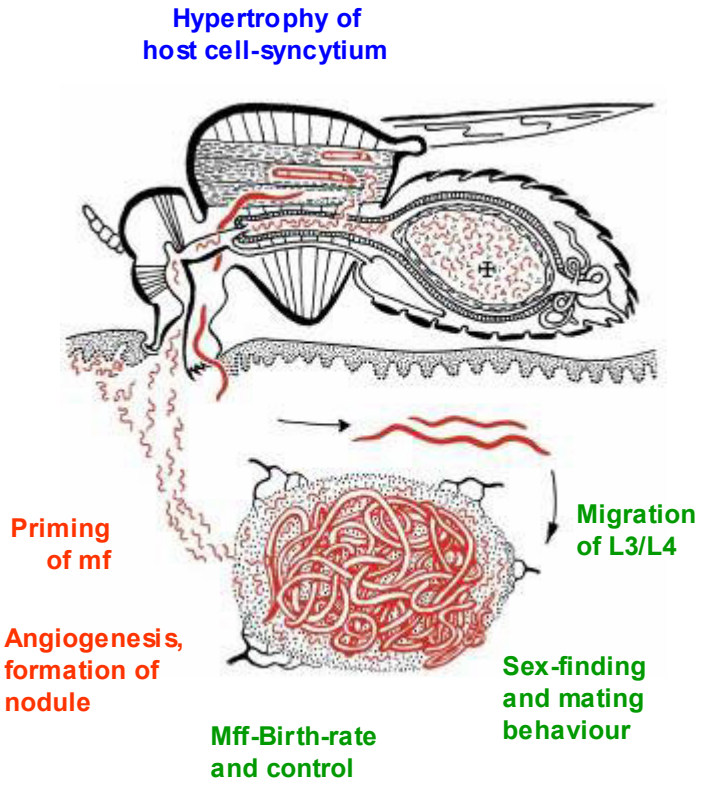
4-800x concentrated

Protein bands female: **10-15** / **25** / **30** / **40** / 50 / 75 Male: **10-15** / 20 / 30 / **40** kDa

N. Brattig
K. Manchang

ES-product and putative function	MW	Immuno-modulating Activity (M. Breleur, BNI)
OV 7 Onchocystatin	18 kDa	Suppression (+ control)
OV 103 microfilariae surface-associated protein	16 kDa	no modulation
RAL 2 Immunodominant hypodermal antigen	19 kDa	no modulation
MIF-1 macrophage migration inhibitors factor-1	12 kDa	no modulation
OVSOD *Onchocerca volvulus* superoxid-dismutase		no modulation
NLT 1 novel larval transcript 1	24 kDa	suppression
ALT 1 abundant larval transcript 1	16 kDa	suppression
ALT 2 abundant larval transcript-2	13 kDa	suppression

A. Renz



Parasite-host crosstalk

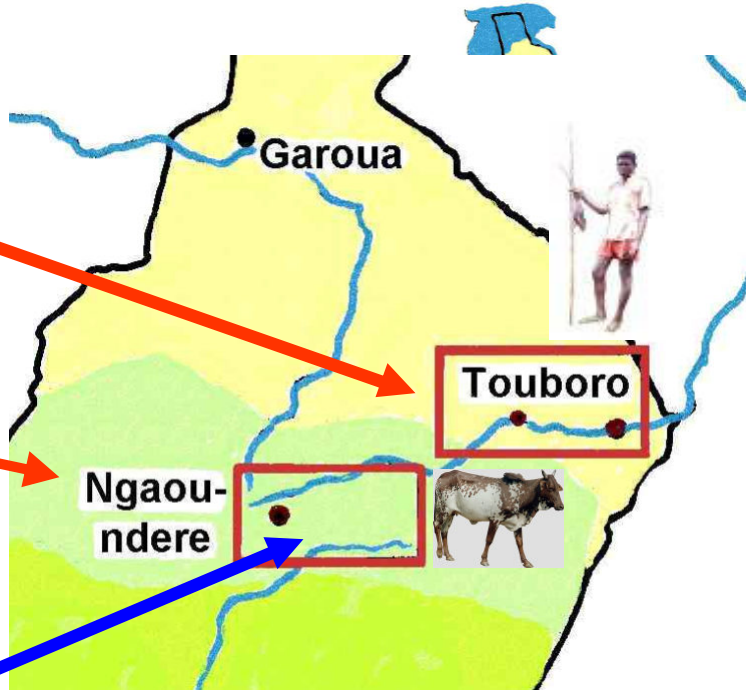
- **parasite intraspecific communication;**
  - density-dependend self-regulation by apoptosis
  - location of nodules and findig of partner, mating and mff-production
- **worm => vertebrate host**
  - induction of nodule-formation
  - angiogenesis
  - immune-stimulation and suppression
- **worm => Simulium vector**
  - hypertrophy of muscle cell (L1-L3)

Back to the field:

⇒ **Longitudinal follow-up of *Simulium* Biting Rates**

and

⇒ ***Onchocerca volvulus* - Transmission Potentials since up to 36 years:**



=> Setup of an experimental cattle herd to study the bionomics of *Onchocerca ochengi*:

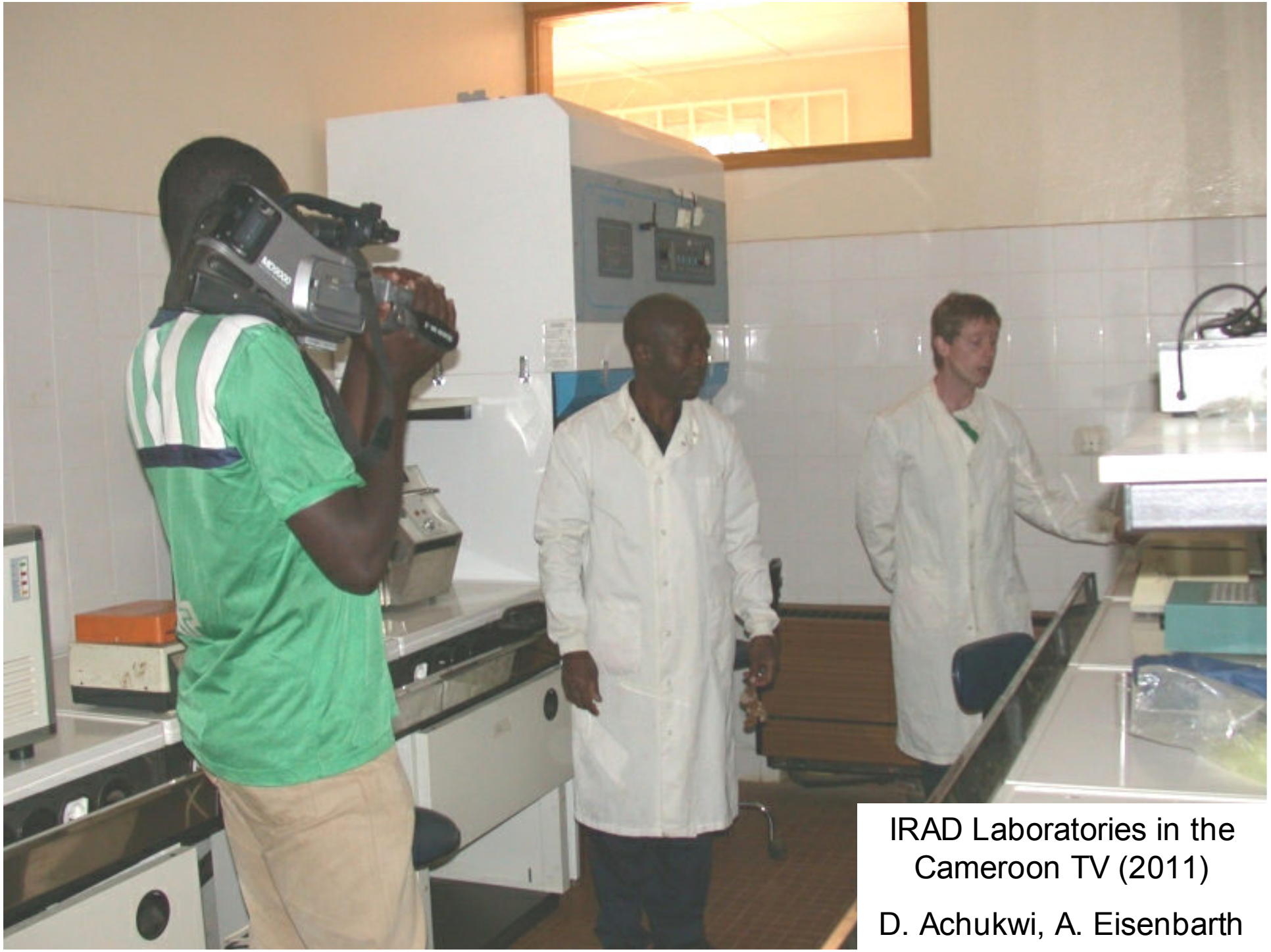
⇒ **regular fly-catches,**

⇒ **dissections of flies**

⇒ **identification of *Onchocerca*-larvae in wild-caught *Simulium* flies**

Institute of Agricultural Research for Development (IRAD), Wakwa Center, 8 km SE from Ngaoundere


Laboratory and administrative buildings of IRAD, Wakwa
(IRAD = Institut de Recherches Agronomiques pour le Dévéloppement)
Build in 1985 with funding from the European Community, this research Center is studying live-stock management and cattle diseases on the Adamaoua highlands. It is a partner in our projects since 1987.
IRAD



IRAD Laboratories in the Cameroon TV (2011)

D. Achukwi, A. Eisenbarth

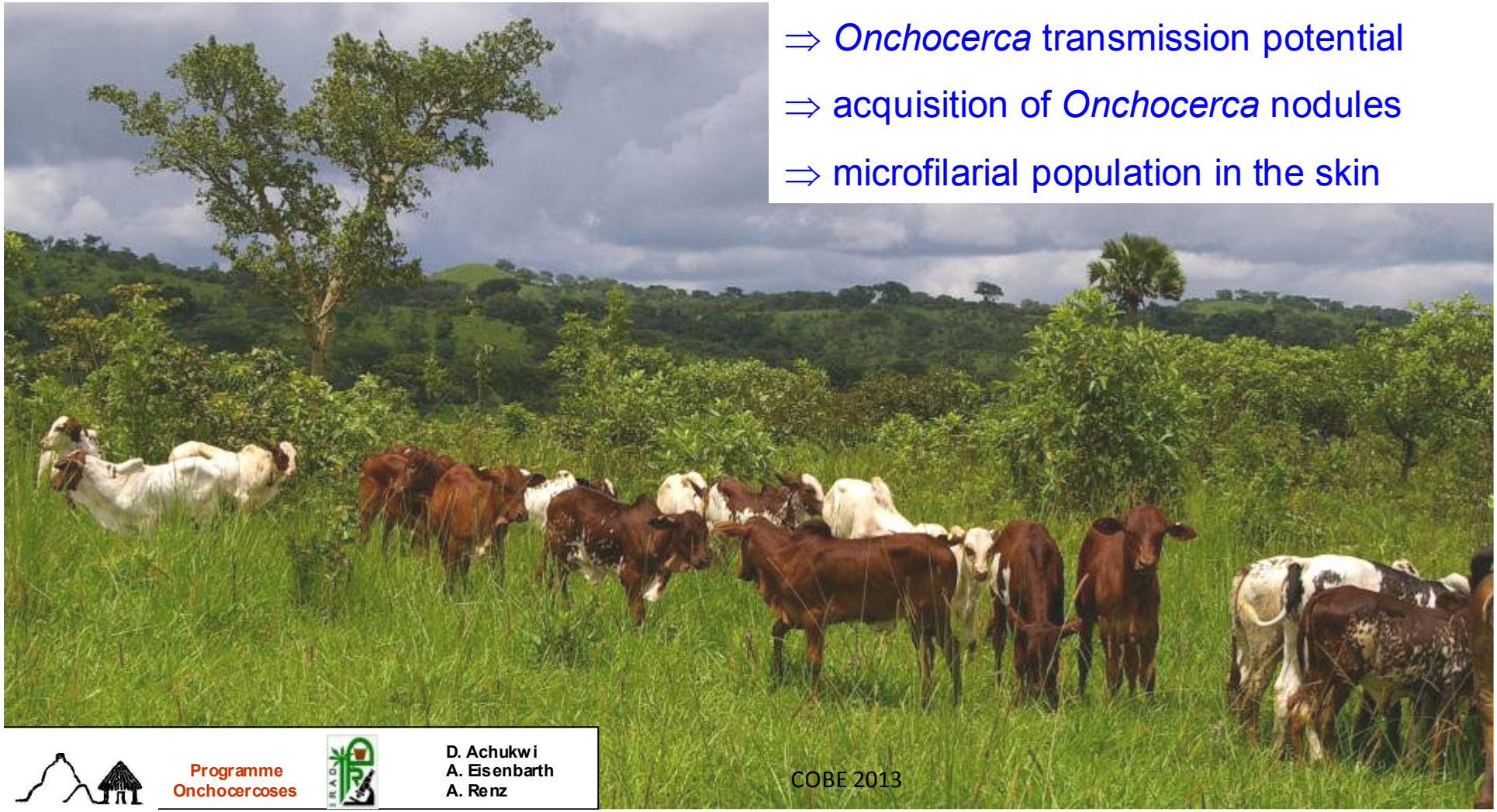
30 calves at the River Vina du Sud exposed from birth to natural transmission

⇒ monitor *Simulium* biting rates

⇒ *Onchocerca* transmission potential

⇒ acquisition of *Onchocerca* nodules

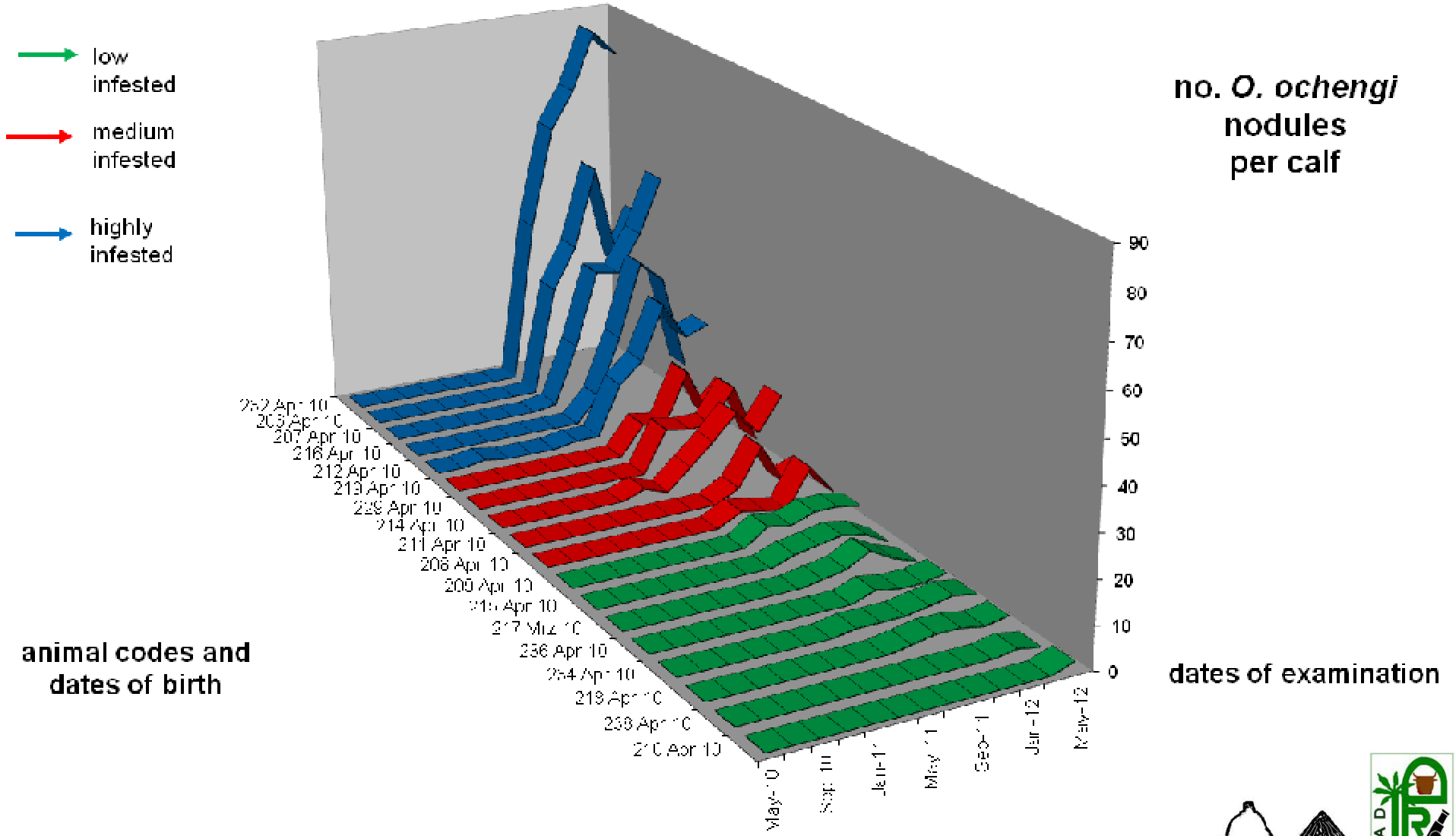
⇒ microfilarial population in the skin



Programme Onchocercoses

D. Achukwi
A. Eisenbarth
A. Renz

After 2 years of exposure: Acquisition of *Onchocerca ochengi* nodules in cattle



A. Eisenbarth, D. Achukwi, A. Renz

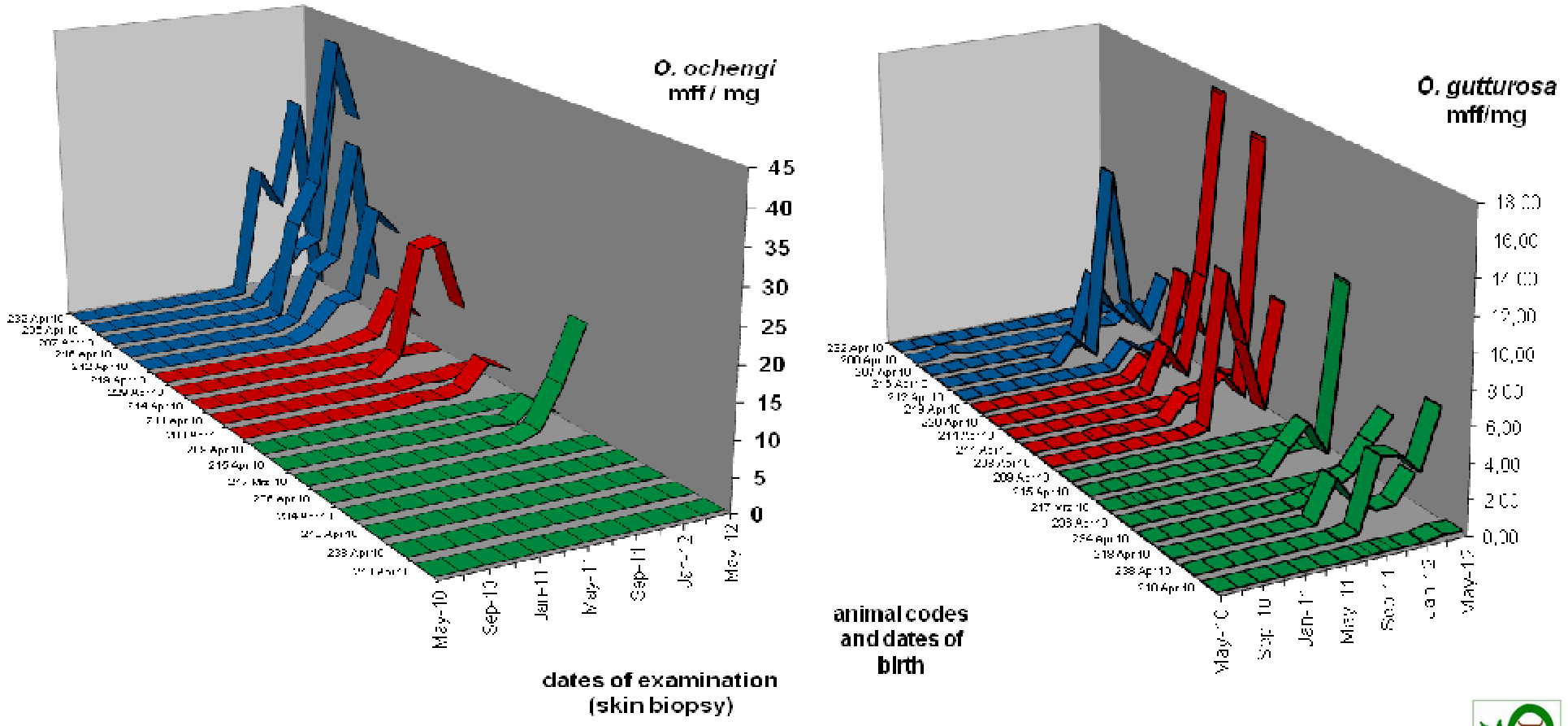
COBE-Project objective:

How shall the acquisition of nodules and the density of microfilariae in the skin of cattle continue over the full duration of parasitosis?

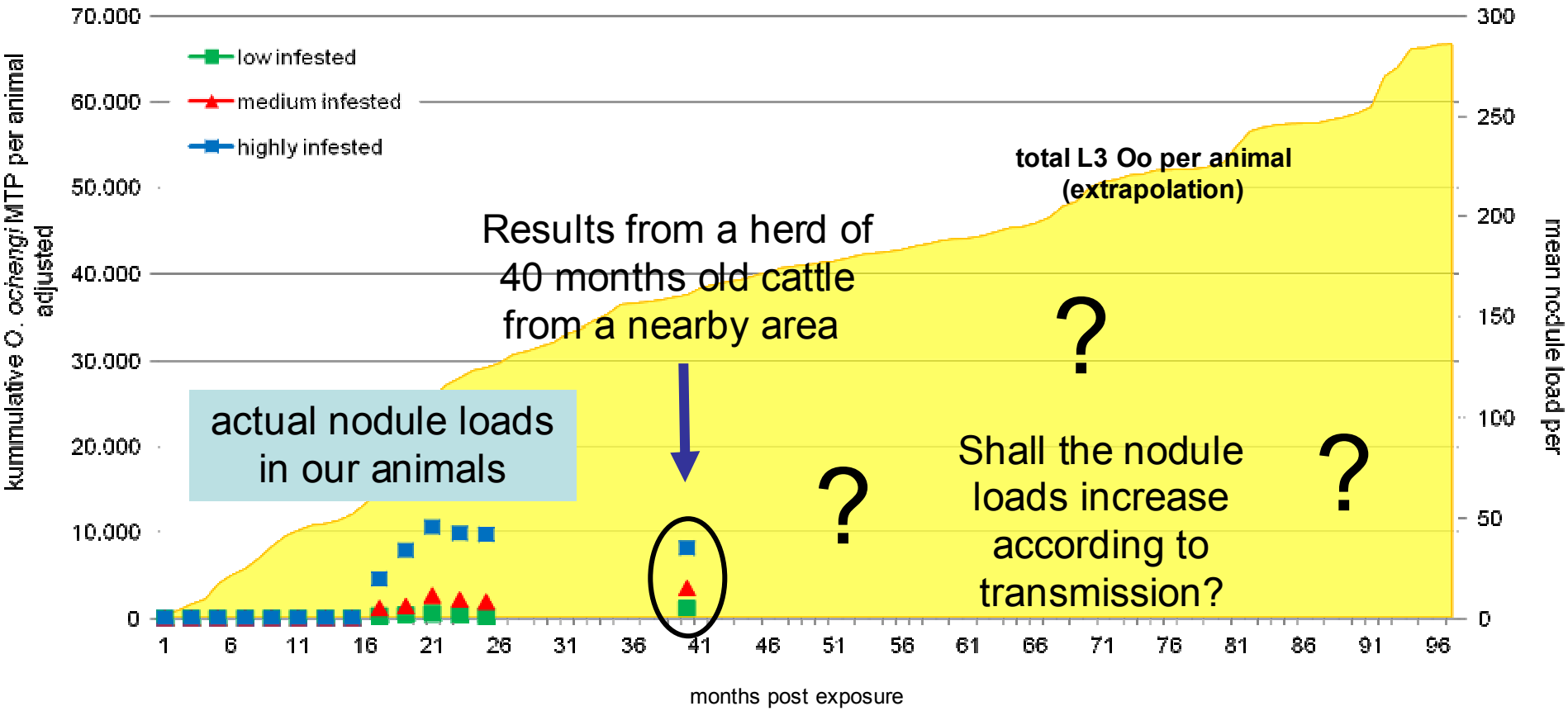
As the worms survive most probably can survive for 6 years´ (or even longer!), the build-up of the worm-populations shall continue for the same period. Only after 7 years, a steady state of turn-over is to be expected!

In human onchocerciasis, where O. volvulus survives for 10 to 15 years, this status is reached at the age of 25 to 30 years.

After 2 years of exposure: Acquisition of microfilarial densities in the ventral skin *Onchocerca ochengi* (left) and *O. gutturosa* (right)



...expected results, when observed over 8 years:



- **we expect data on parasite acquisition, turnover, life expectancy**
- **influence of premunition (↑) and immuno-suppression (↓)**
- **is resistance against adult worms or microfilariae stable or does it change over life-time?**
- **how do immunological parameters in the blood of cattle correlate with their parasite loads?**

Expected answers from the bovine model:

Population biology of *Onchocerca ochengi*:

- quantitative data on L3-development rates
- self-regulation of the worm load
- sex-finding and mating
- territory defence of adult worms
- longevity and turn-over of worm-population

Genotyping of single worms and microfilariae, implantation of L3 / L4 into subcutaneous microcapsules

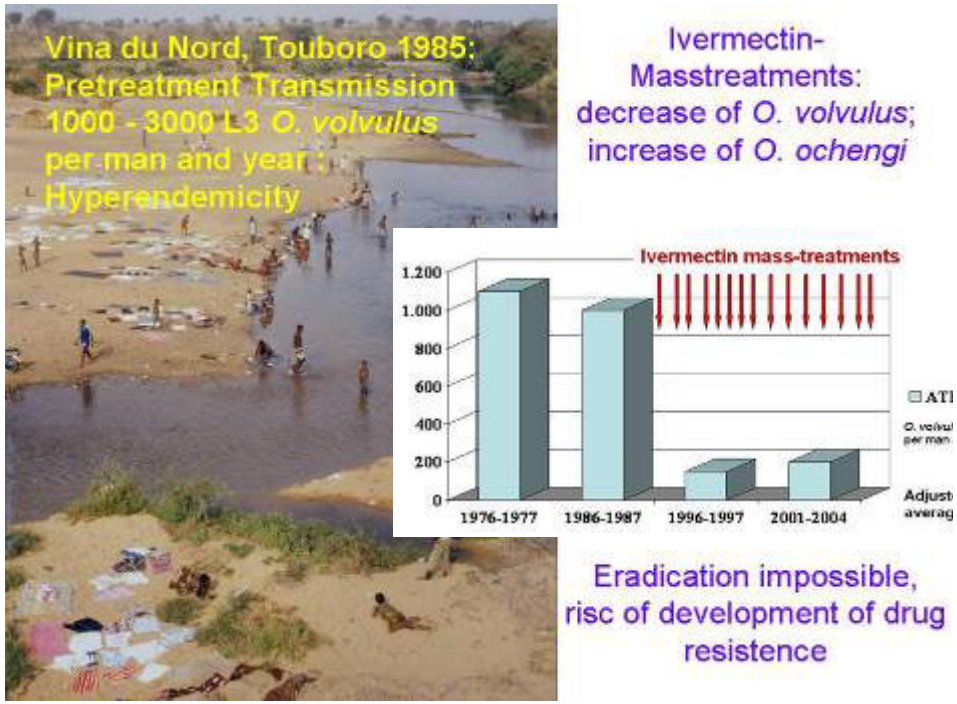
training of students !

=> Students of biology & veterinary science from Ngaoundére and Germany do their practical work on this cattle herd (parasitological, entomological and immunological studies)

Can onchocerciasis be eliminated?

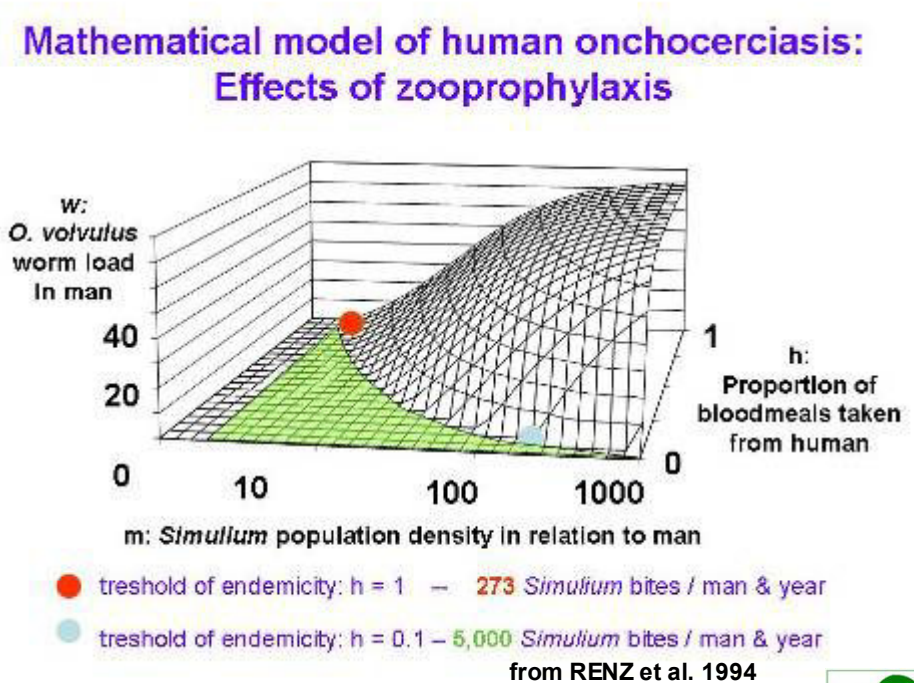
Our data from Northern Cameroon (Vina du Nord valley) show, that transmission still continues after 25 years of annual Ivermectin mass-treatments. However, zoophrophylaxis by cattle has a beneficial effect in reducing transmission of human onchocerciasis on the Adamaoua-highland.

According to the zoophily of the *Simulium* vector populations (proportion of bloodmeals on man), the threshold levels for endemicity is between 273 and 5.000 flies (h=1 and h=0,1, after Renz et al. 1994). Levels of ATP should probably be well below 10 L3 per man and year, a level that is very difficult to assess by dissection of flies.

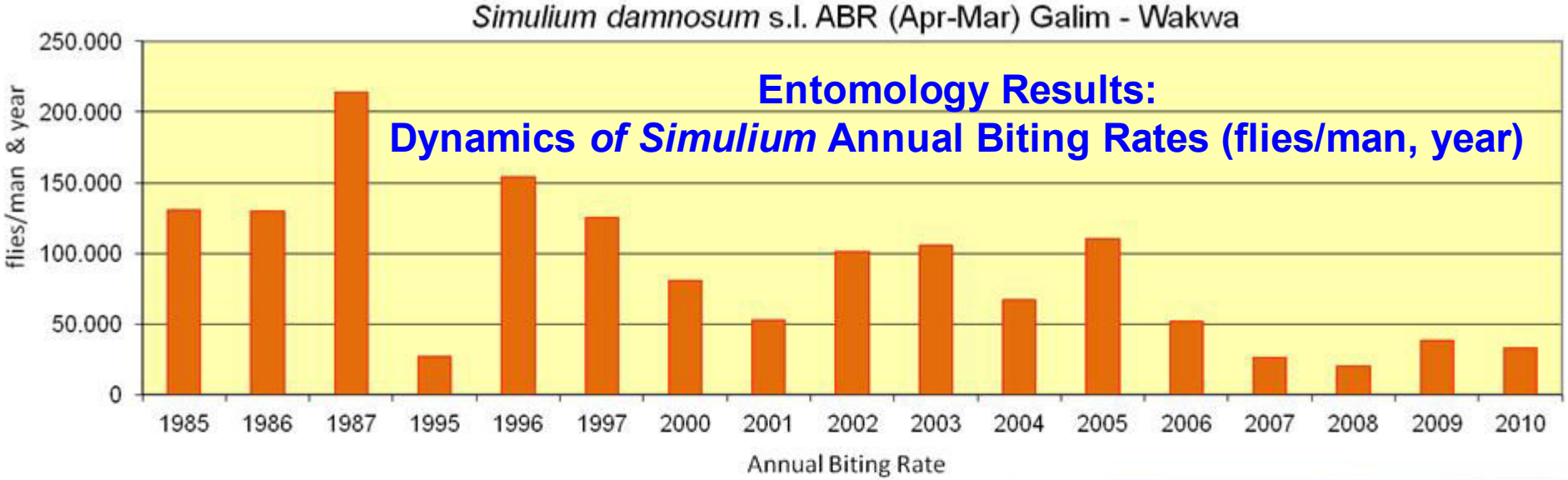


Ivermectin-Masstreatments: decrease of *O. volvulus*; increase of *O. ochengi*

Eradication impossible, risc of development of drug resistence

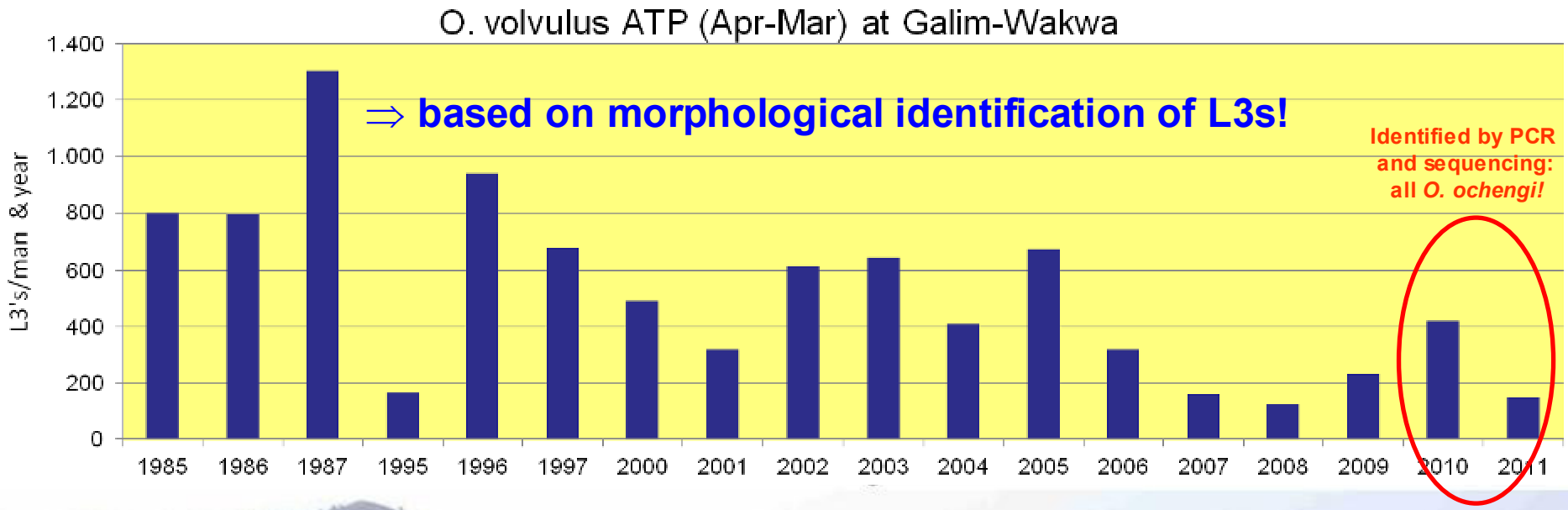


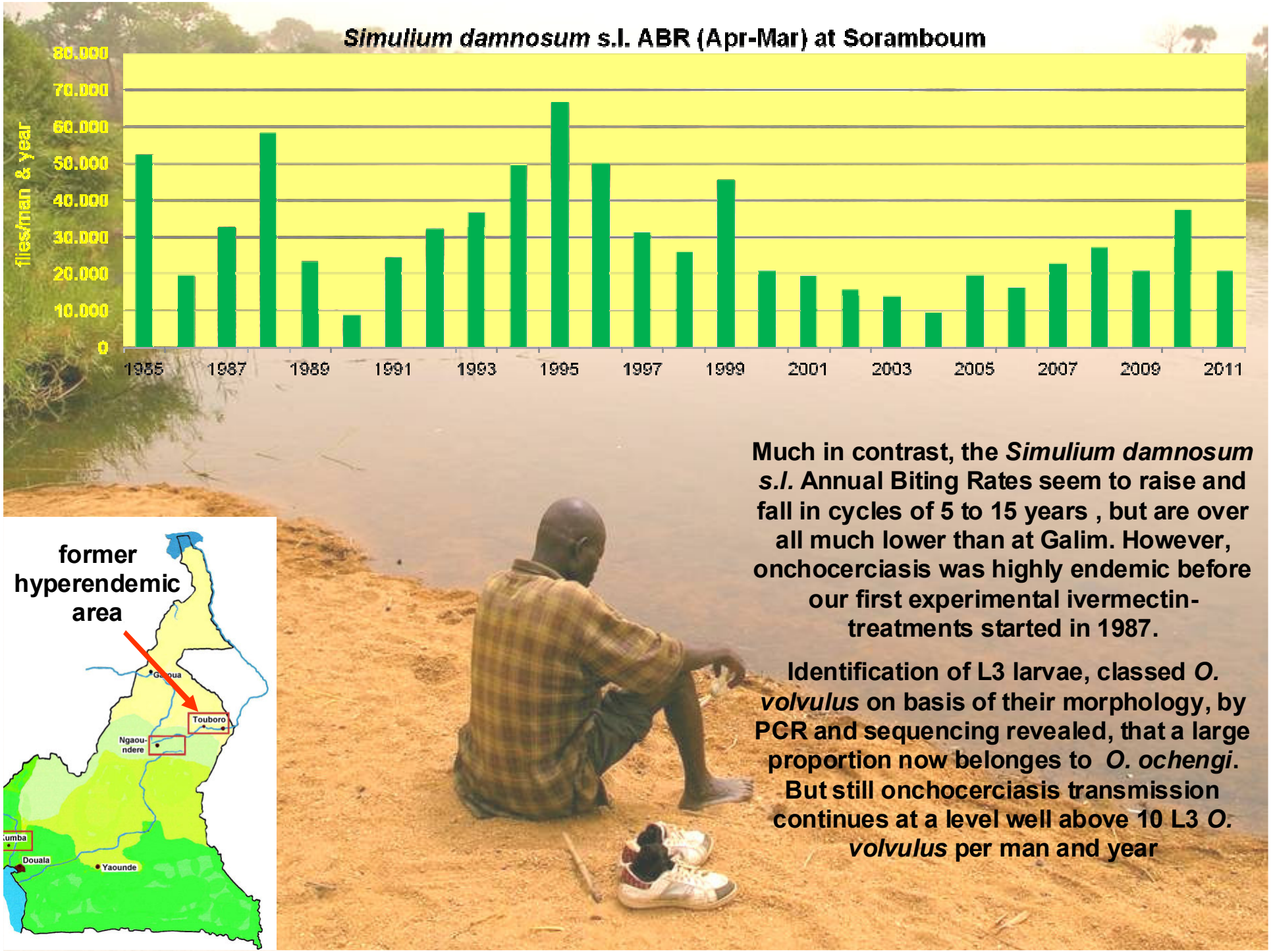
from RENZ et al. 1994



Since 1985, we monitore the *Simulium* Biting Rates on man at the Vina du Sud near Ngaoundéré (Galim). Biting rates were extremely high, up to over 200.000 flies per man and year, but seem to have declined since, for yet unknown reasons

A. Eisenbarth, A. Renz, D. Ekale


O. volvulus ATP (Apr-Mar) at Galim-Wakwa
L3's/man & year
1.400
1.200
1.000
800
600
400
200
0
1985
1986
1987
1995
1996
1997
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
⇒ based on morphological identification of L3s!
Identified by PCR and sequencing: all O. ochengi!


Simulium damnosum s.l. ABR (Apr-Mar) at Soramboum
flies/man & year
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
former hyperendemic area
Touboro
Ngaoundere
Douala
Yaounde
Much in contrast, the Simulium damnosum s.l. Annual Biting Rates seem to raise and fall in cycles of 5 to 15 years , but are over all much lower than at Galim. However, onchocerciasis was highly endemic before our first experimental ivermectin-treatments started in 1987.
Identification of L3 larvae, classed O. volvulus on basis of their morphology, by PCR and sequencing revealed, that a large proportion now belonges to O. ochengi. But still onchocerciasis transmission continues at a level well above 10 L3 O. volvulus per man and year

In our earlier studies from 1976 to 1979, the village Mayo Galke, situated at the river-banc of the *Simulium*-breeding river Mayo Re was the example for hyperdenemicity, with many eye-lesions

Precontrol hyperendemicity, 2000 L3 *O. volvulus* / man,year

=> construction of a cotton factury in 1980

=> rapid socio-economic development, ivermectin treatments since 1990

Mayo Galke in 2012 => nowadays, onchocerciasis seems under control !

Capacity building, training of students & collaboration

- Setup of functional *in-vitro*, immunology and molecular biology laboratories at IRAD, Wakwa and at the Programme Onchocercoses lab of the University of Tübingen in Ngaoundéré
- Entomological, parasitological and epidemiological techniques for field-work
- Oncho-presentation in the villages
- 9 Cameroonian and 4 German students trained in Cameroon
- 6 Cameroonians trained in Germany
- workshop with 50 participants from Germany & Cameroon

Oncho-Lab, Ngdéré

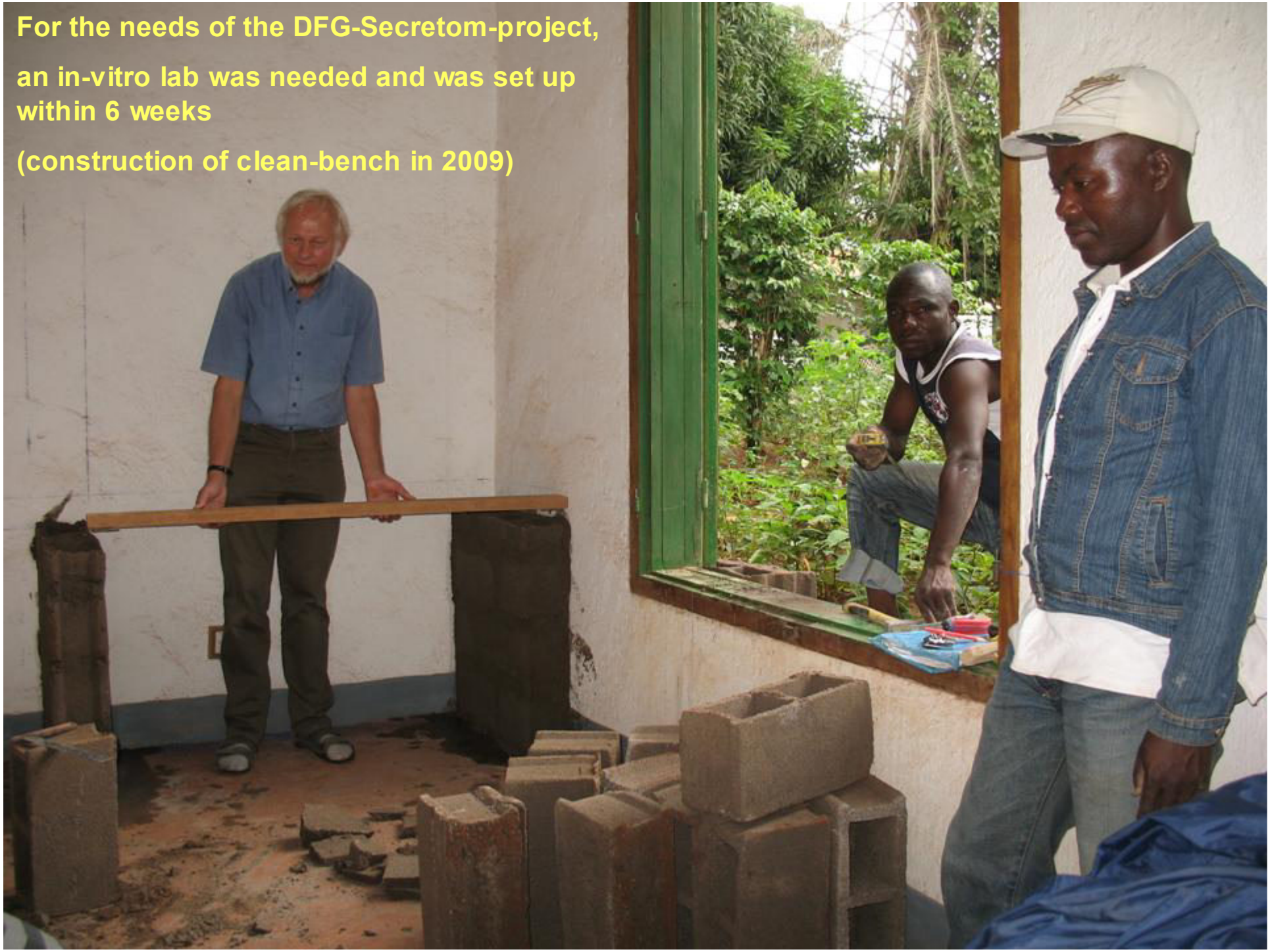
In 1996, our project moved to a new site in Ngaoundéré. However, these old colonial houses had first to be renovated. Within 6 weeks, the new lab was set up!

Set-up of the laboratory in 1996, construction of lab-bench


The lab-bench in 2011

The Programme Oncho-Lab in 2012

Laboratory and garden in 2012


For the needs of the DFG-Secretom-project,
an in-vitro lab was needed and was set up within 6 weeks
(construction of clean-bench in 2009)


Sarah Reiling and
Cameroonian students
working at the new clean-bench

The new molecular-biology lab, constructed by Albert Eisenbarth in 2012
(Jeremie preparing the PCR-samples)

Perception among local authorities and communities

- **36 years of field-work** in Cameroon
- Successfull collaboration with local authorities and institutions
- The project is extremely well received and recognized
- Control of human onchocerciasis **(river blindness)** is based on our epidemiological field studies

Meeting with provincial health-delegate and Mectizan-distributors

Jury master defence, Uni Ngdere, March 2011

Teaching & Training

Cameroon

Students

Stephanie Maier (Tü)
Daniela Renz (Tü)
Anna van Hoorn (HH)
Silke van Hoorn (HH)
Sarah Reiling (Tü)
Tobias Schräder (Mü)
Constance Mebatu (UN)
Achille Paguem (UN)
Babette Abanda (UN)
Nancy Ngwasiri (UN)

Scientists

Alfons Renz (Tü)
Albert Eisenbarth (Tü)
Mark Bronsvoort (UK)

Workshop

Medical Entomology
9 Tübingen students
40 Ngaoundéré students

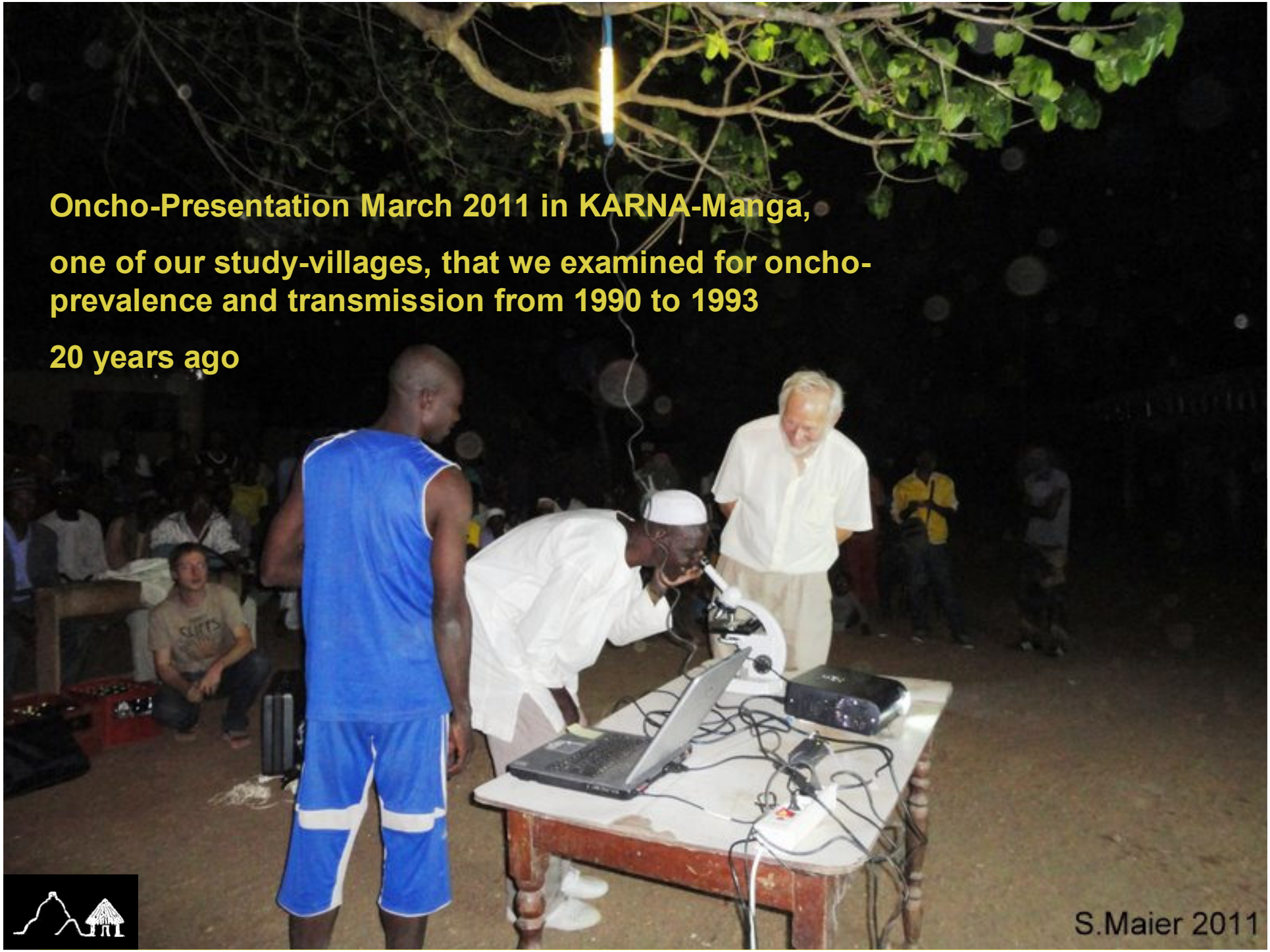
Germany

Djafsia Boursou (HH)
Nancy Ngwasiri (HH)
Jaqueline Diktie (Mü)
Eko Boloko (Mü)
David Ekale (Nigeria)
Dieudonné Ndjonka (Mü)
Daniel AchuKwi (TÜ, HH)
Kingsley Manchang (HH)

⇒ **Conclusion:**

Research on the biology, immunology and control of *Onchocerca* parasites is still a priority. Especially now, that good results from the mass-chemotherapy suggest that control came close to the elimination of the parasite. Yet there is a high risk of recrudescence of the parasite, when resistance would turn up or control measures would be reduced, which both is likely to occur.

Apart from this, *Onchocerca ochengi* provides an unique model for studying the population biology and immunology of nematode parasites


Oncho-Presentation March 2011 in KARNA-Manga,
one of our study-villages, that we examined for oncho-prevalence and transmission from 1990 to 1993
20 years ago
S.Maier 2011

Cameroon-seminar in Tübingen WS 2011/2012

In preparation of the excursion to Cameroon, 15 students in Tübingen participated in a seminar, which included a variety of topics, from parasitology, ecology and ethnology to Cameroonian cooking.

Medical Entomology & Parasitology workshop in Cameroon, Feb-March 2012

=> 9 students from Germany

=> 40 students from Univ. Ngaoundéré

Medical Entomology, Parasitology & Epidemiology Workshop
University of Ngaoundéré, Feb-March 2012

PCR for identification of Onchocerca-L3

Observation of *Simulium*-feeding trial

9 German and 40 Cameroonian participants

Simulium-breeding sites, examination of larvae, ‘magic-cow’-fly-trap, fly-catching on cow

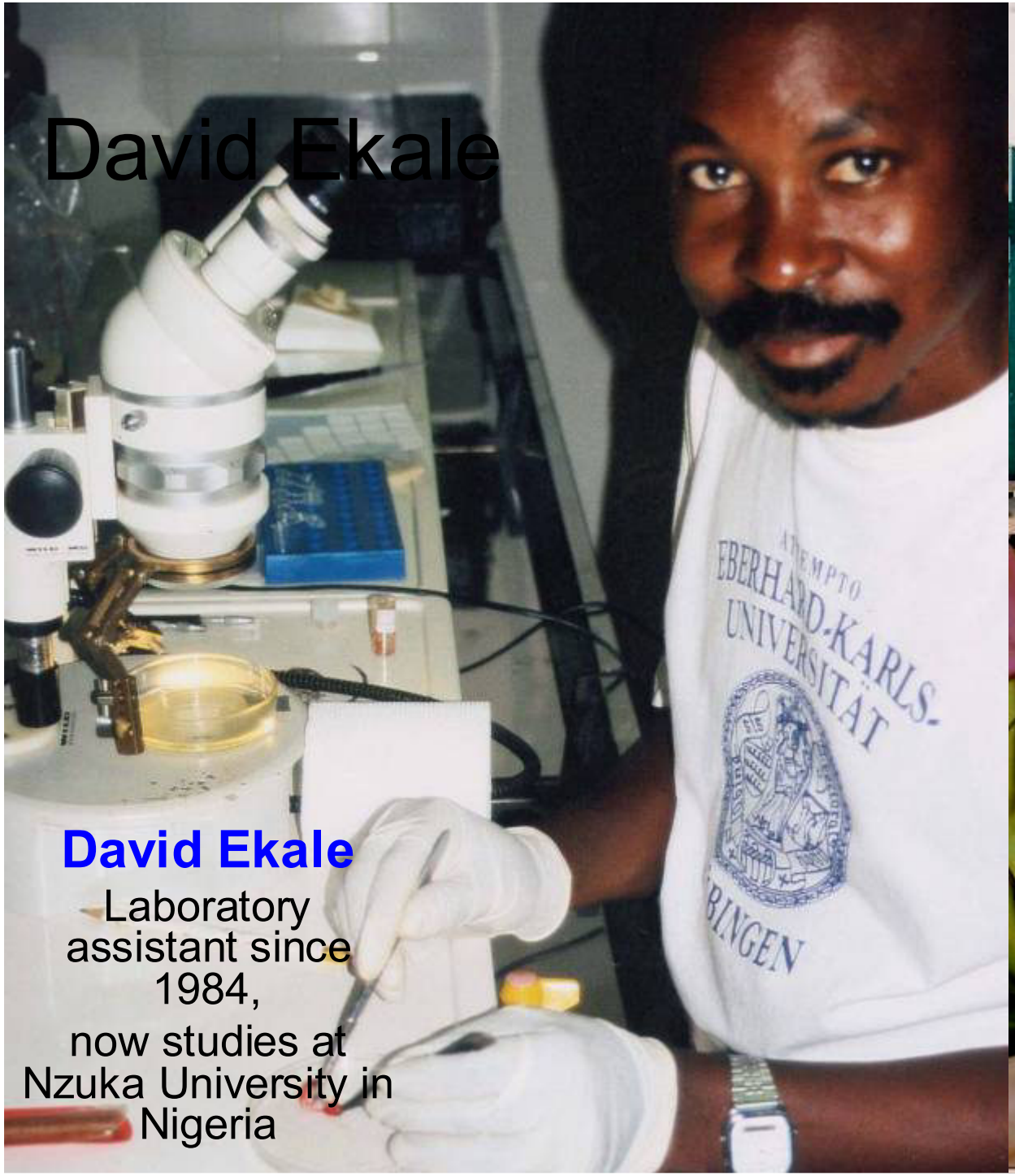
Magic Cow

- Anflug u. Landeverhalten der Kriebelmücken (*Simulium spec.*)

- Auffinden des Wirtes
  - optisch / olfaktorisch?
  - CO_2, Urin, Rinderhaut…

- Unterschiede beim Anflugverhalten im Vergleich zum Menschen

David Ekale



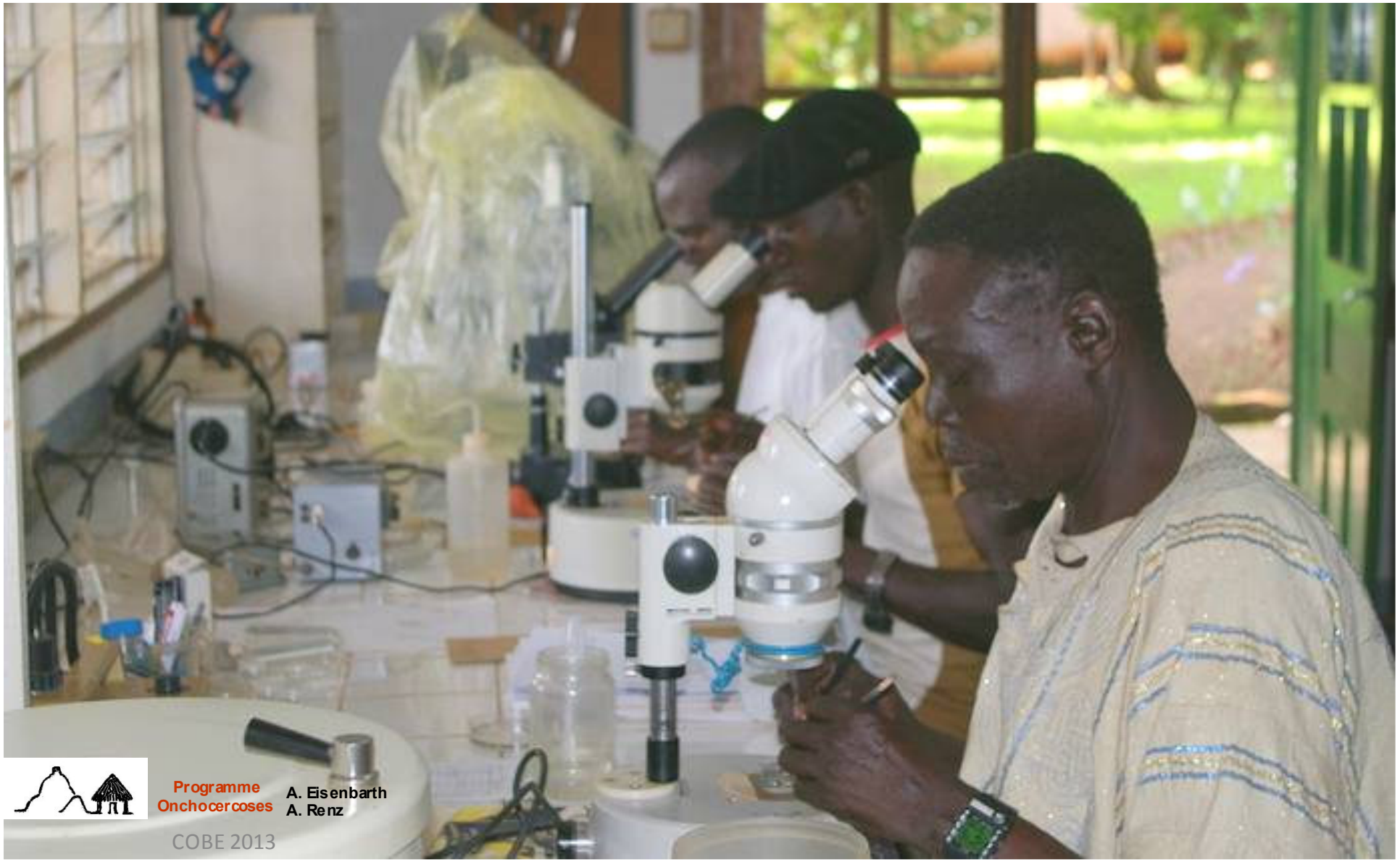
David Ekale

Laboratory assistant since 1984,

now studies at Nzuka University in Nigeria

Production of **E**xcretory-**S**ecretory-**P**roducts (**ESP**s) worm isolation, incubation *in vitro* => Ngaoundéré

=> isolation and preparation of adult worms from the abbattory



Programme Onchocercoses

A. Eisenbarth
A. Renz

Preparation and colour coding of worms

Constance Mebatou
&
Ngwasiri Ngwafu

Together with Stefanie Maier, they developed a method for age-grading of adult *Onchocerca* worms, based on the colour of the cuticula.

Teams involved in CGCP

Bernhard-Nocht-Institute for Tropical Medicine
Kingsley Tanyi,
Djafsia Boursou
Marie-Luise Eschbach,
Silke van Horn,
PD Dr. Norbert Brattig
PD Dr. Minka Breloer

IRAD
Veterinary Research Laboratory
4 Students/co-worker
Dr. Daniel Achukwi

University of Tübingen
Programme Onchocercoses
Albert Eisenbarth
Stephanie Maier
Daniela Renz
Sarah Reiling, David Ekale
PD Dr. Alfons Renz

University of Ngaoundere
Faculty of Life Sciences
4 Students/co-worker
Dr. Dieudonne Ndjonka

...and special thanks to...
- Dr. D. Becher, Institute for Microbiology, University of Greifswald
- Dr. S. Binder, Helmholtz Centre for Infection Research

University of Münster,
Institute of Animal Physiology
Irene Ajonina
Marc Kurosinski
Sinan Altioglu
Prof. Kai Lüersen
Prof. Dr. Eva Liebau

University of Hamburg
Institute for Biochemistry
Ralph Eberle
Dr. Markus Perbandt
Prof. Dr. Christian Betzel

Deutsche Forschungsgemeinschaft DFG

Alexander von Humboldt Stiftung/Foundation

DAAD

Photo by Silke van Horn

Teams involved in COBE

Bernhard-Nocht-Institute for Tropical Medicine
Kingsley Tanyi,
Marie-Luise Eschbach,
Silke van Horn,
PD Dr. Norbert Brattig
PD Dr. Klaus Ertmann

IRAD
Veterinary Research Laboratory
4 Students/co-worker
Prof. Daniel Achukwi

University of Tübingen
Programme Onchocercoses
Albert Eisenbarth
Babette Guimbang
Daniela Renz
Archile Paguem, David Ekale
PD Dr. Alfons Renz

University of Ngaoundere
Faculty of Life Sciences
4 Students/co-worker
Prof. D. Achukwi

...and special thanks to...
- Dr. D. Becher, Inst. f. Microbiology, Univ. Greifswald
- Dr. S. Binder, Helmholtz Centre for Infection Research

Max-Planck-Institute
Dept. Develop. Biology

Dipl. biol. J. Hildebrandt
PD. Dr. Adrian Streit

University of Bamenda

Faculty of Sciences

Dr. Ngouemain Ngoufo

Deutsche Forschungsgemeinschaft DFG

DAAD

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Deutsch-Afrikanische Kooperation

DFG-Projekte