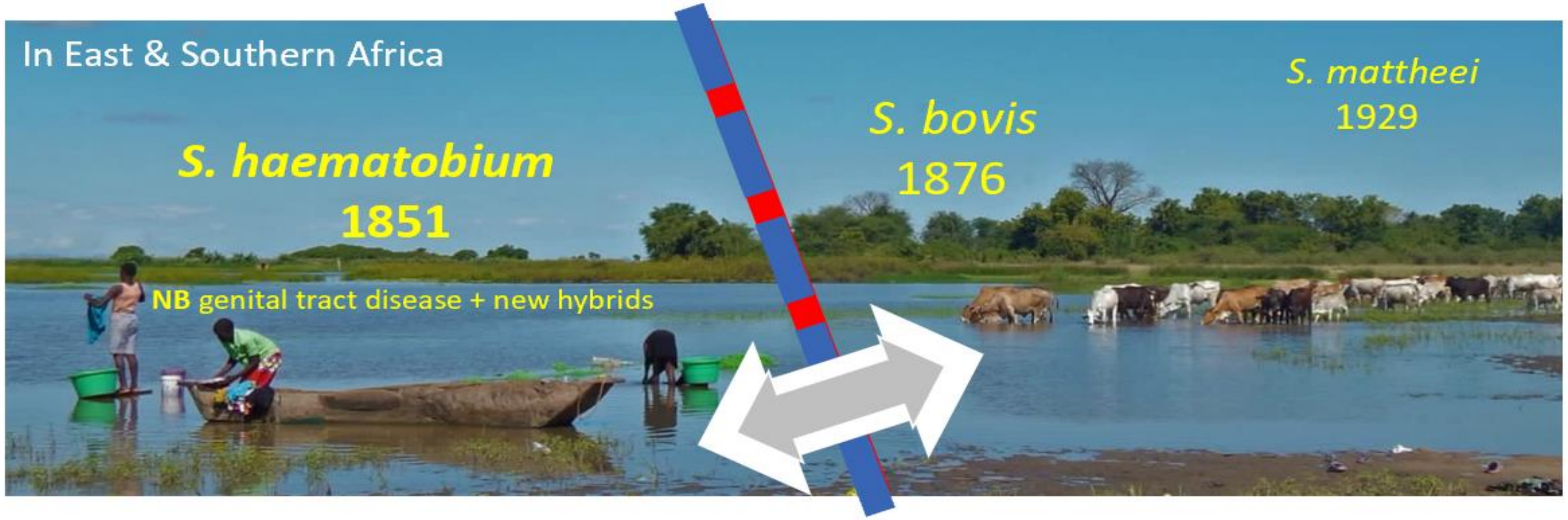
ECTMIH Chairs: Russell Stothard (UK) & Govert van Dam / *Lisette van Lieshout* (NL)

A FOCUS ON MALAWI: SCHISTOSOMIASIS & A NEW ONE HEALTH



In memoriam
Lazarus Juziwelo

1970-2022

Topics & speakers

Origins of schistosome hybrids	- Tine Huyse (BE)
HUGS human studies	- Janelisa Musaya (MALW)
HUGS snail studies	- Peter Makaula (MALW)
HUGS cattle studies	- Alexandra Juhasz (HU/UK)
GPS livestock tracking methods	- Julianne Meisner (UK/USA)

A FOCUS ON MALAWI

SCHISTOSOMIASIS & A NEW ONE HEALTH

Origins of schistosome hybrids - Tine Huyse (BE)

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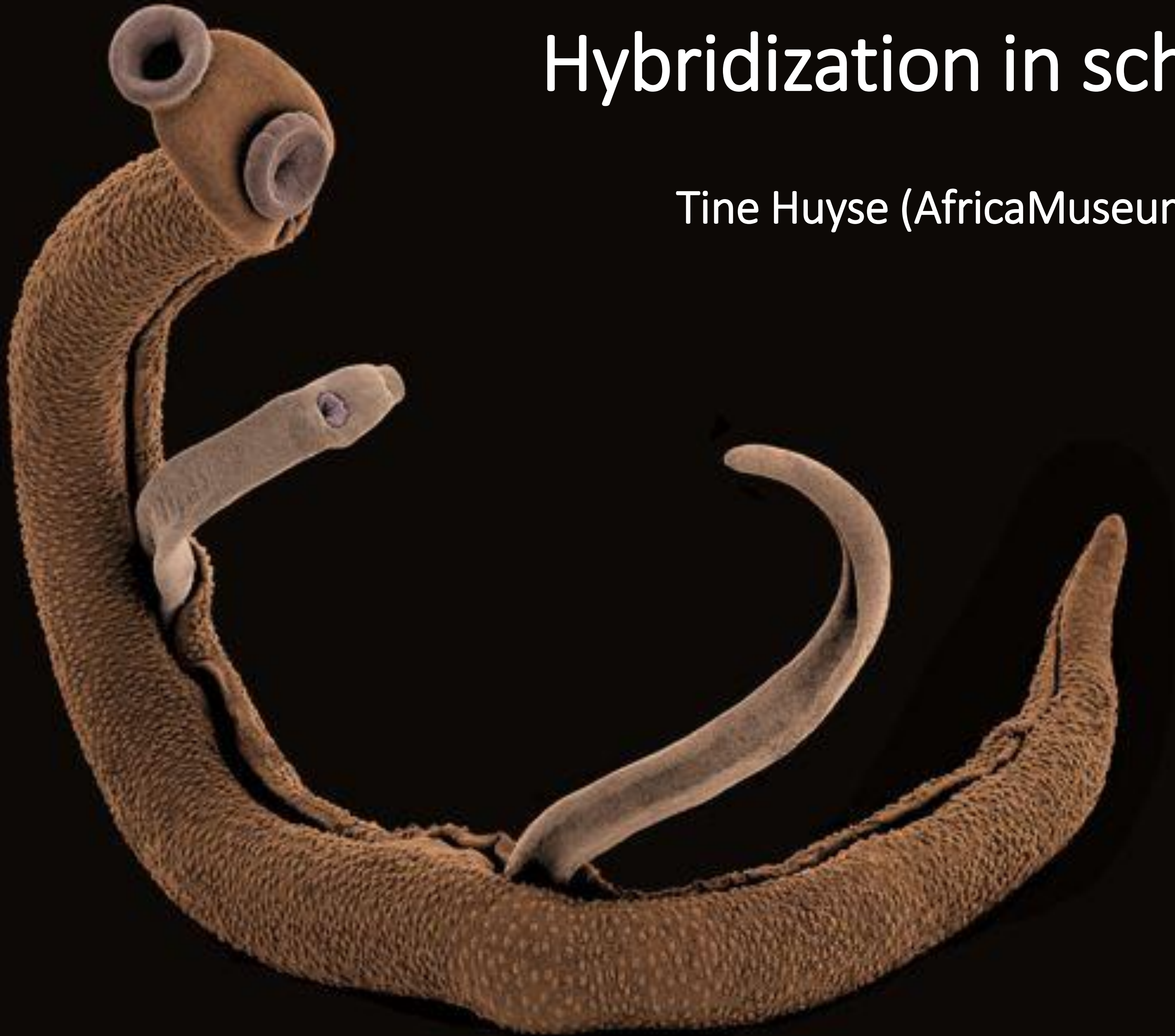


Hybridization in schistosomes

Tine Huyse (AfricaMuseum, Belgium)

schistós; soma

Kinshasa, 1954
Collection RMCA

INTRASPECIFIC INTERACTIONS

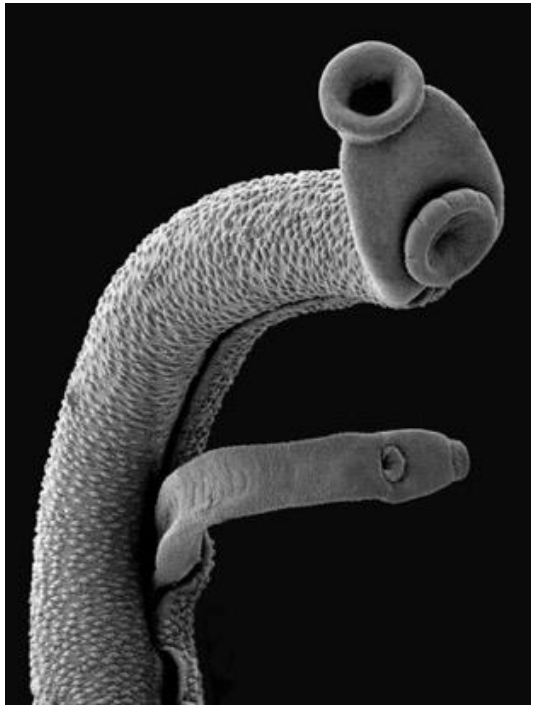
- Only genus of digenean parasites with sexual reproduction: partner choice

OPEN ACCESS Freely available online — PLoS one

Genetic Dissimilarity between Mates, but Not Male Heterozygosity, Influences Divorce in Schistosomes

Sophie Beltran[1], Frank Cézilly[2], Jérôme Boissier[1]*

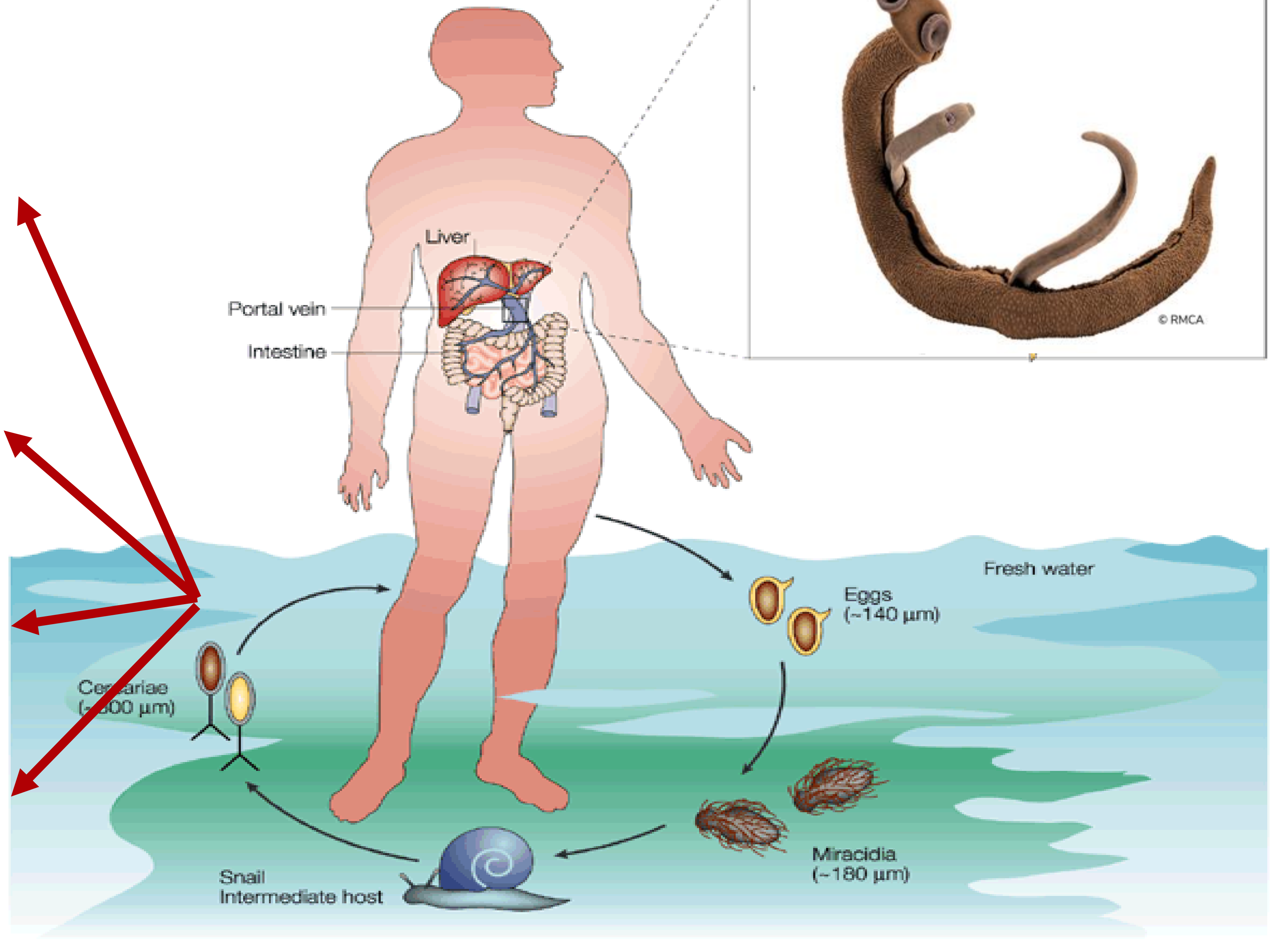
- Male bias → male-male competition



RMCA

Steinauer: The sex life of parasites IJP 2009

Schistosomiasis



Nature Reviews | Immunology

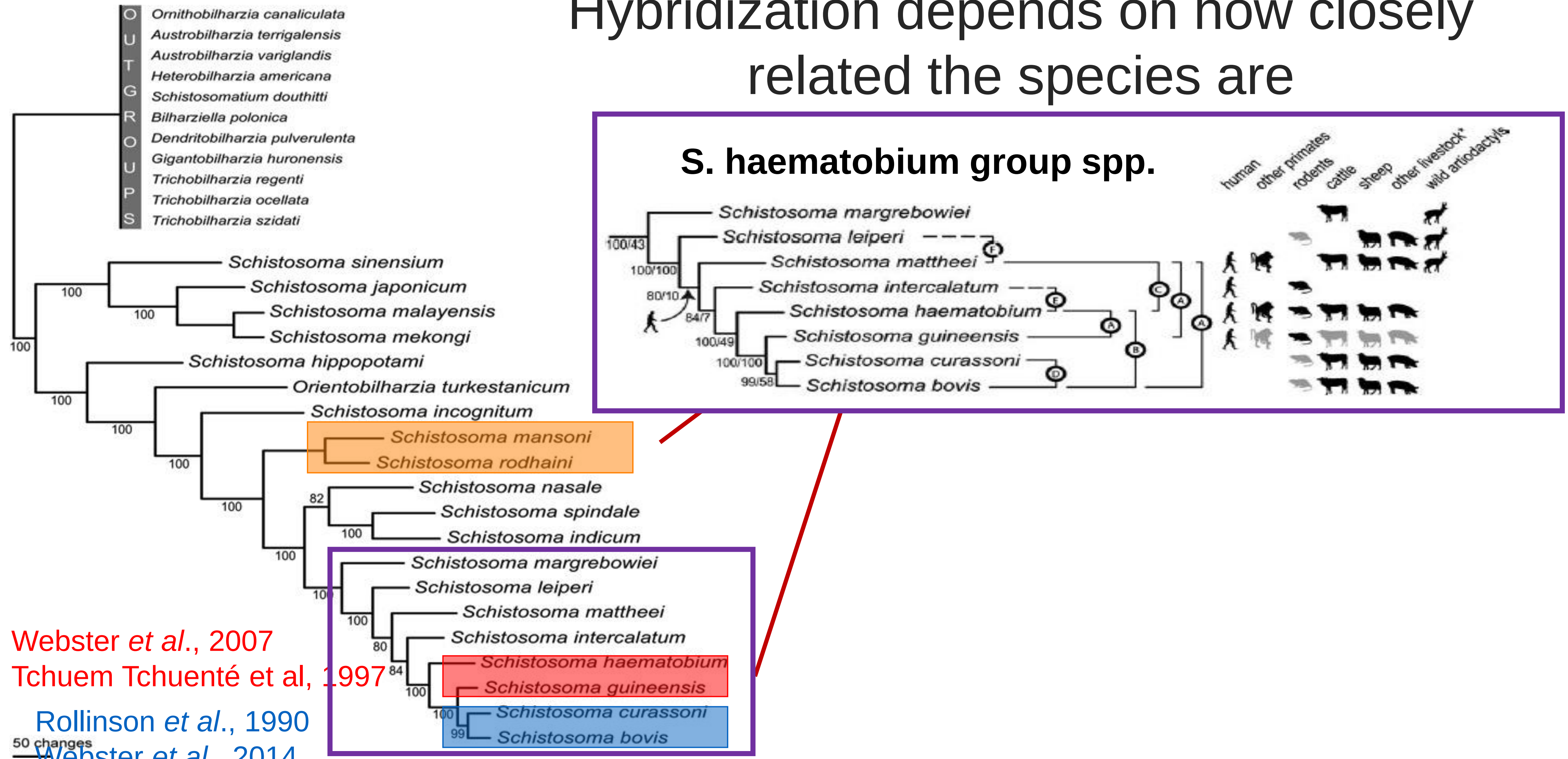
INTERSPECIFIC INTERACTIONS

Competitive exclusion

Pairing between different species

- parthenogenesis (nonviable eggs)
- hybridization

Hybridization depends on how closely related the species are



Webster *et al*., 2007
Tchuem Tchuenté et al, 1997

Rollinson *et al*., 1990
Webster *et al*., 2014

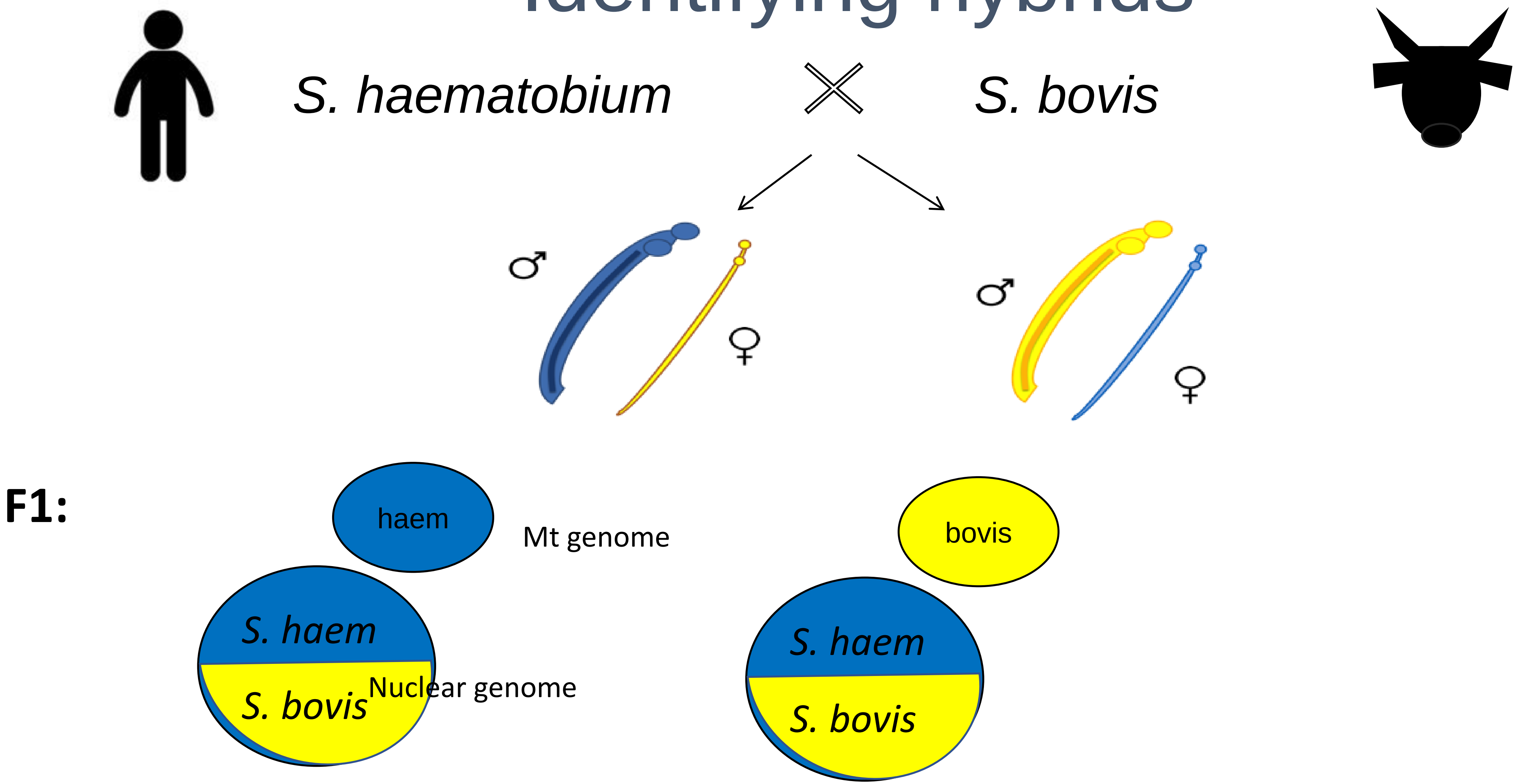
Webster *et al*, 2006

HYBRIDIZATION

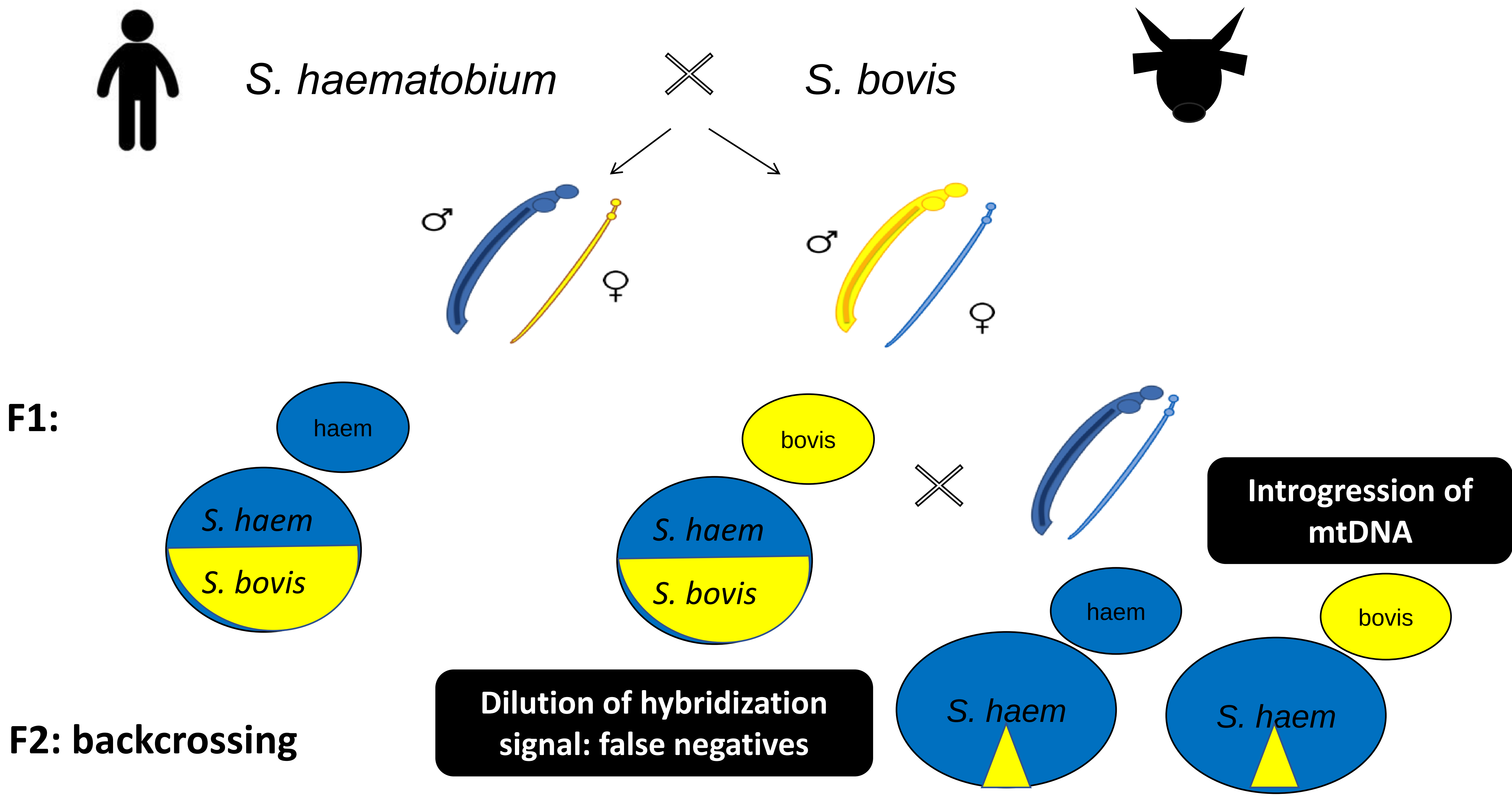
- bridge between two species → exchange genes → introgression
- Leads to increased genotypic variation
- Leads to phenotypic variation (altered host range, virulence, maturation time, drug sensitivity, etc).
- Hybrid vigour (Taylor, 1970; Wright and Ross,1980, Webster et al., 2006 etc)

→ Evolutionary innovations in arms race with their hosts

Identifying hybrids



"discordance between nuclear and mitochondrial markers"

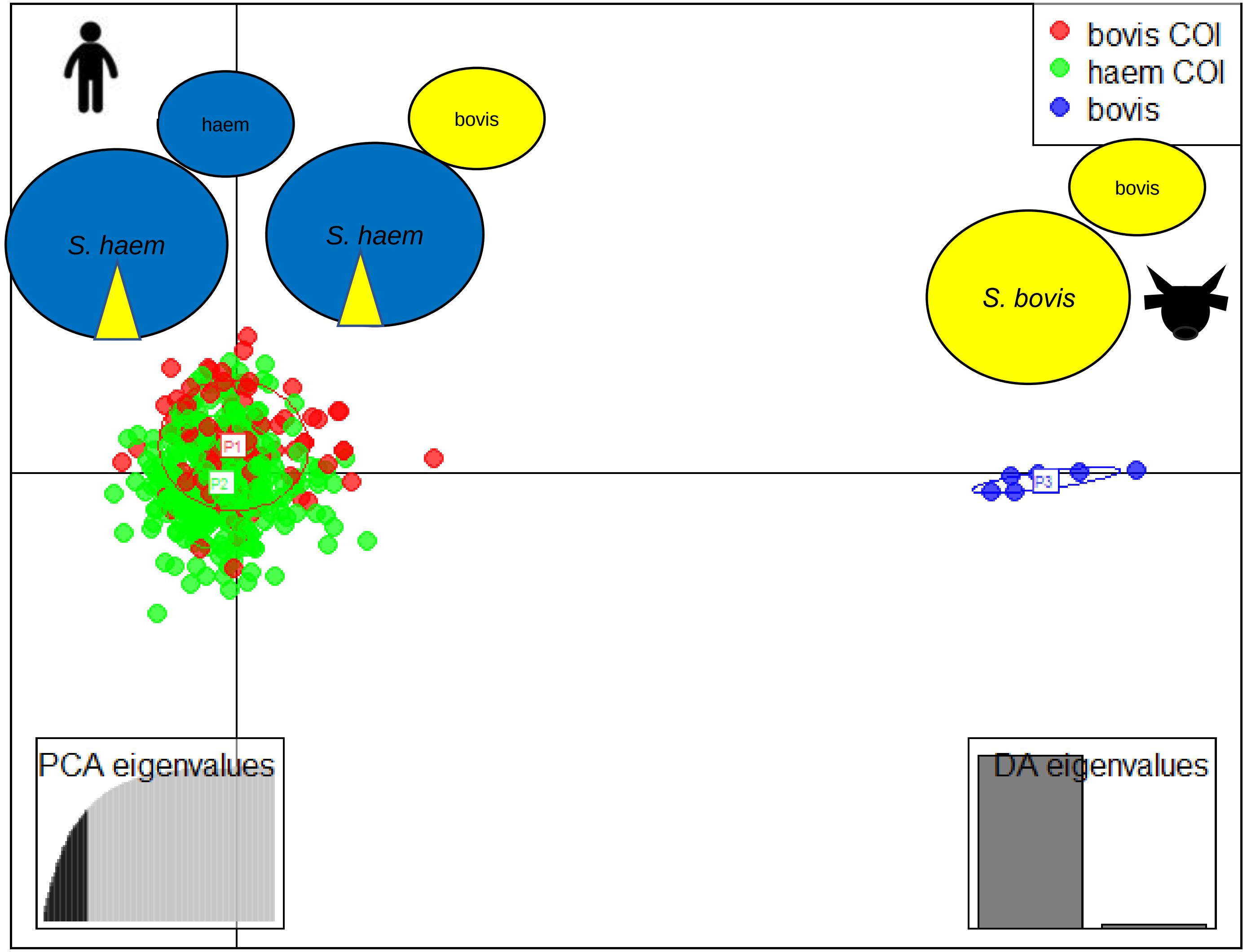


S. haematobium
S. bovis
♂
♀
♂
♀
F1:
haem
S. haem
S. bovis
bovis
S. haem
S. bovis
Introgression of mtDNA
haem
bovis
S. haem
S. haem
Dilution of hybridization signal: false negatives
F2: backcrossing

Identification problems

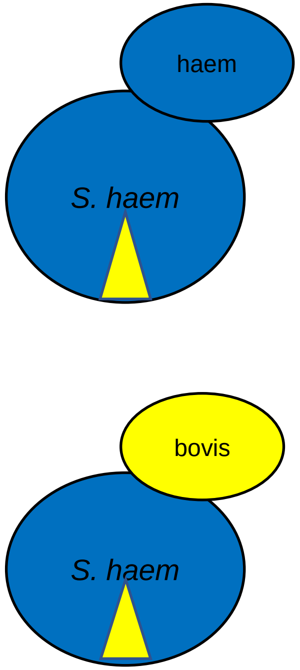
Mt barcoding (COI)

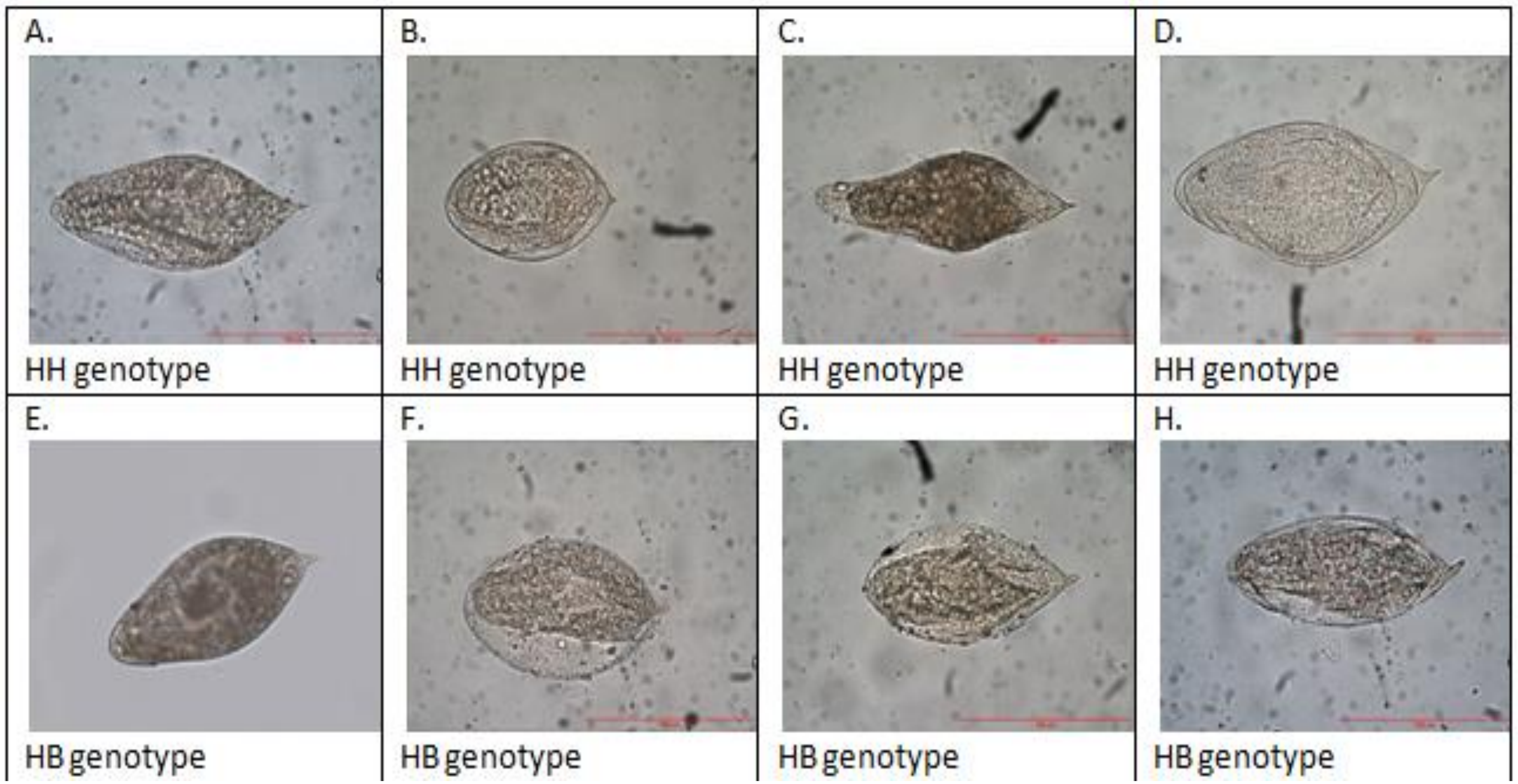
Nuclear microsats (n=17)



Boon et al, 2018

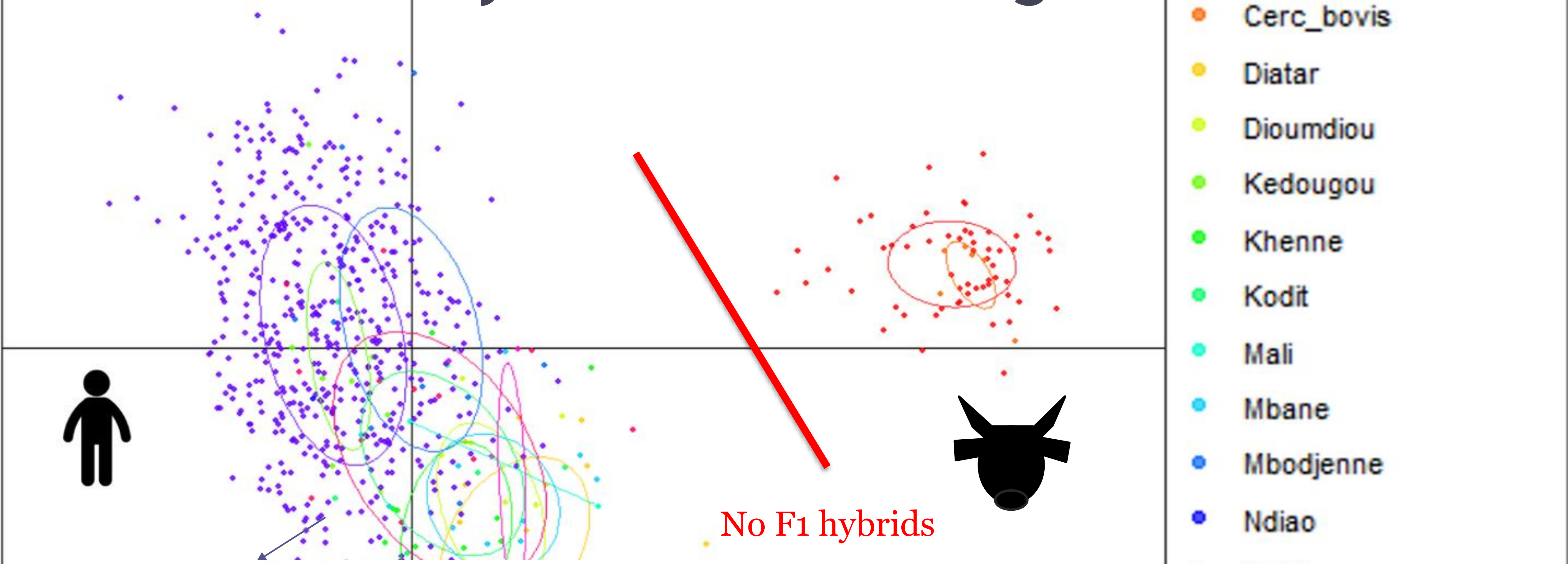
Identification problems





Boon et al, 2016

No recent hybridisation Senegal



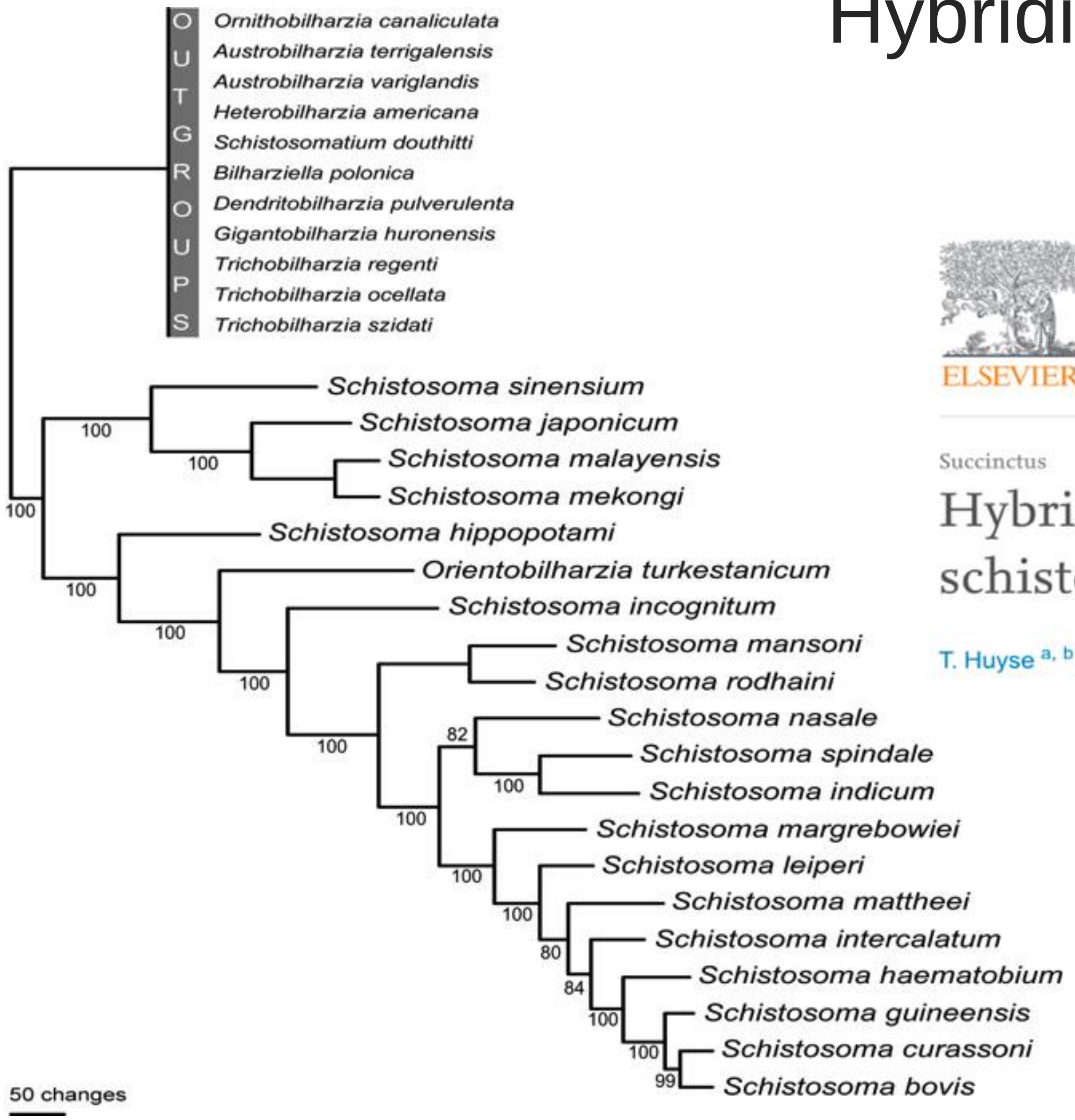
Ancient Hybridization and Adaptive Introgression of an Invadolysin Gene in Schistosome Parasites

Roy N Platt, II, Marina McDew-White, Winka Le Clec'h, Frédéric D Chevalier, Fiona Allan, Aidan M Emery, Amadou Garba, Amina A Hamidou, Shaali M Ame, Joanne P Webster ...
Show more

Molecular Biology and Evolution, Volume 36, Issue 10, October 2019, Pages 2127–2142, https://doi.org/10.1093/molbev/msz154

Boon et al, 2018

Hybridization depends on how closely related the species are



Webster *et al*, 2006

ELSEVIER
International Journal for Parasitology
Volume 43, Issue 8, July 2013, Pages 687-689

Succinctus

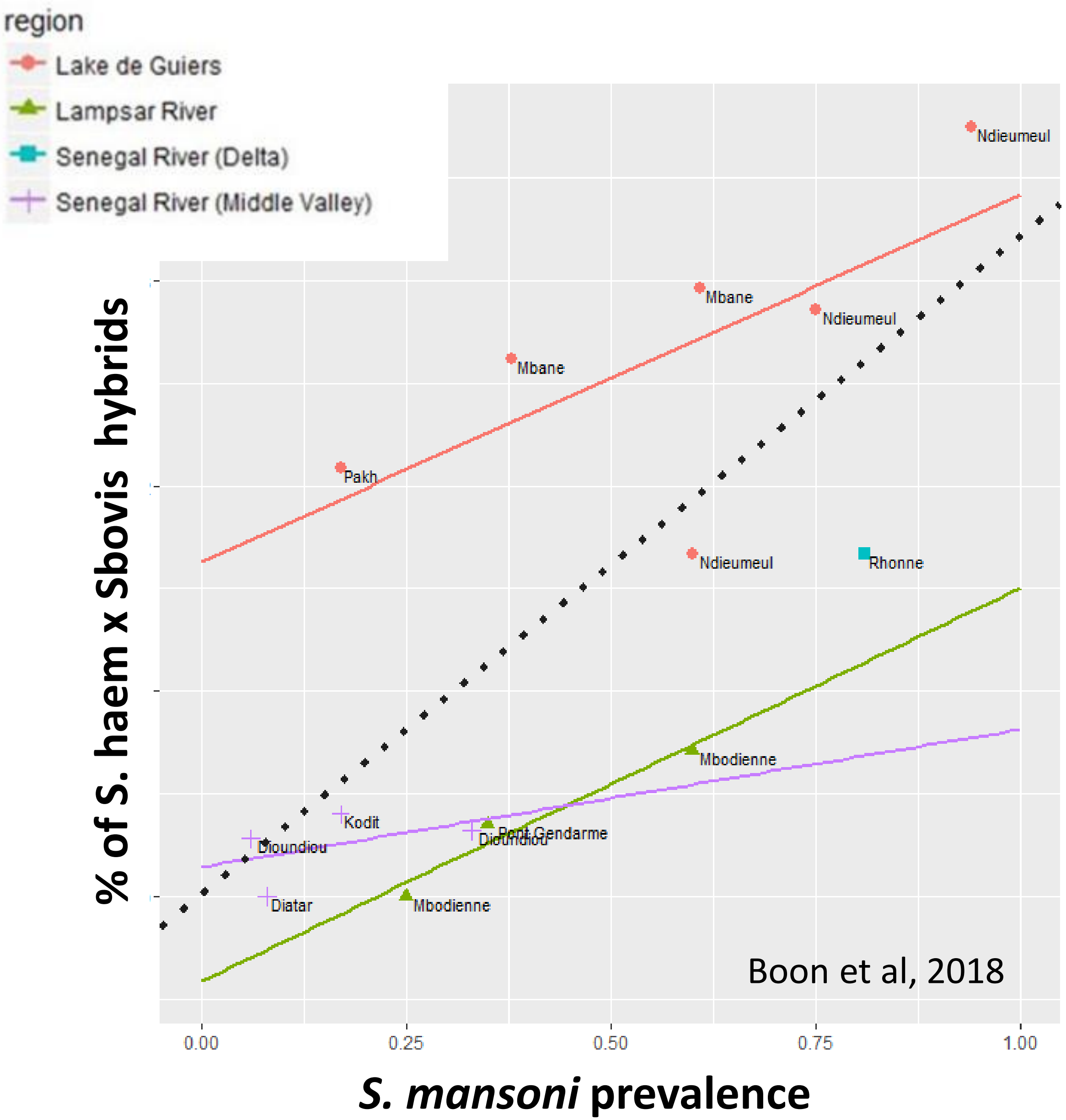
Hybridisation between the two major African schistosome species of humans

T. Huyse [a, b], F. Van den Broeck [a, b], B. Hellemans [b], F.A.M. Volckaert [b], K. Polman [a]

Emerg Infect Dis. 2019 Feb; 25(2): 365–367.
doi: 10.3201/eid2502.172028
PMCID: PMC6346478
PMID: 30526763

Schistosoma haematobium–Schistosoma mansoni Hybrid Parasite in Migrant Boy, France, 2017

Yohann Le Govic, Julien Kincaid-Smith, Jean-François Allienne, Olivier Rey, Ludovic de Gentile, and Jérôme Boissier



Association with *S. mansoni* but not with *S. haematobium*

→ Facilitating role of *S. mansoni*

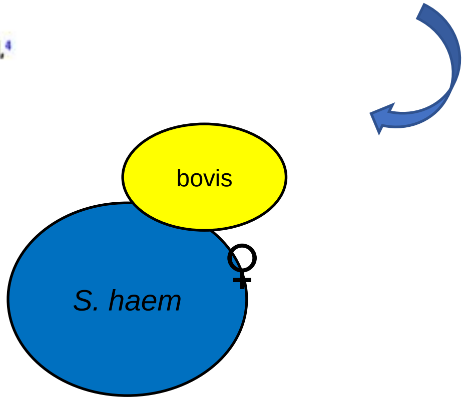

The Journal of Infectious Diseases

BRIEF REPORT

Rodents as Natural Hosts of Zoonotic *Schistosoma* Species and Hybrids: An Epidemiological and Evolutionary Perspective From West Africa

Stefano Catalano,[1] Mariama Sène,[2] Nicolas D. Diouf,[2,3] Cheikh B. Fall,[4] Anna Borlase,[1] Elsa Léger,[1] Khalilou Bâ,[5] and Joanne P. Webster[1]

S. mansoni ♂ x



S. mansoni pre-requisite for *S. mattheei* establishment in humans (Pitchford, 1961)

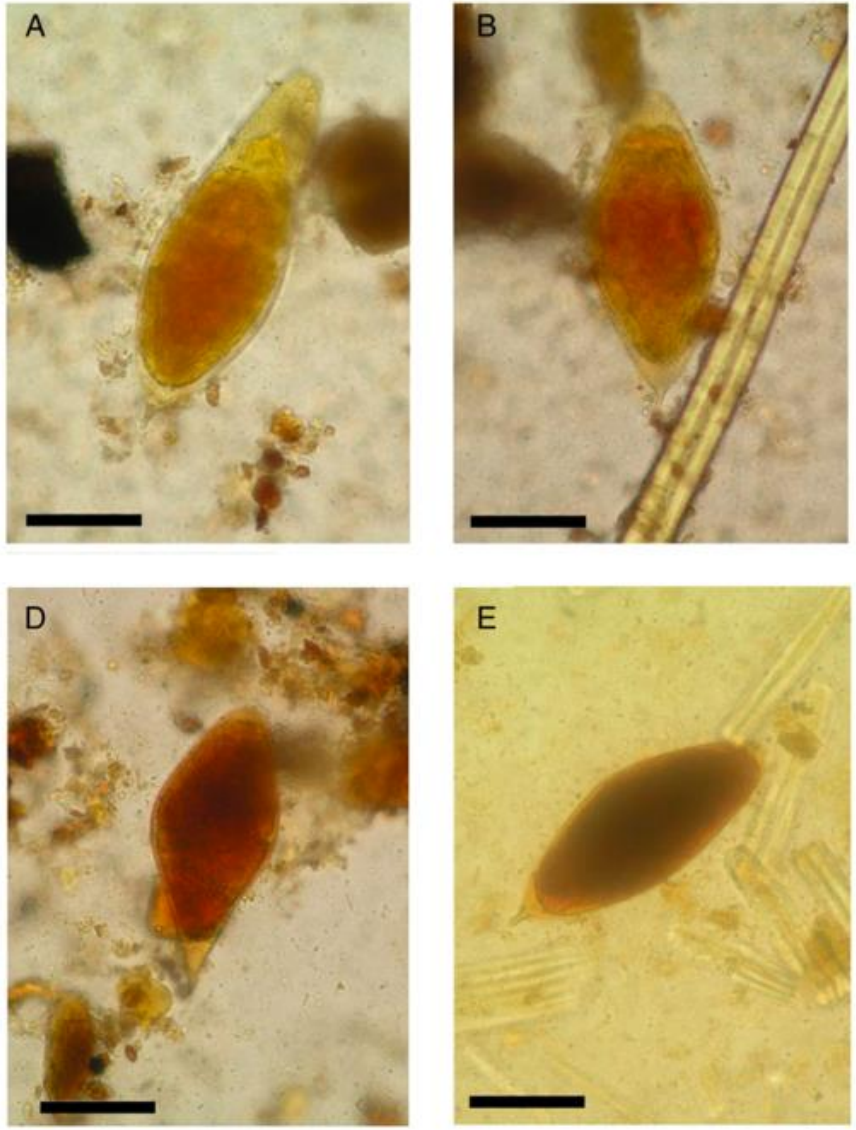
Diagnosis in travellers

Diagnosis and Clinical Management of *Schistosoma haematobium*–*Schistosoma bovis* Hybrid Infection in a Cluster of Travelers Returning From Mali

Patrick Soentjens, Lieselotte Cnops, Tine Huyse, Cedric Yansouni, Daniel De Vos, Emmanuel Bottieau, Jan Clerinx, Marjan Van Esbroeck Author Notes

Clinical Infectious Diseases, Volume 63, Issue 12, 15 December 2016, Pages 1626–1629,

Before Treatment							
ELISA	IHA	Eggs in Stool, No./g	Genus PCR (Stool)	Microscopy (Urine)	Genus PCR (Urine)	Dra PCR (Serum)	Sm1–7 PCR (Serum)
Positive	Negative	Negative	NA	Negative	NA	Positive	Positive
Negative	1/640	Negative	NA	Negative	NA	Positive	Negative
Negative	Negative	360	Positive	Negative	NA	Positive	Positive
Negative	Negative	40	Positive	Negative	NA	Positive	Negative
Negative	1/160	10	Positive	Negative	NA	Positive	Positive
Negative	1/1280	80	Positive	Negative	Negative	Positive	Negative
Negative	Negative	60	Positive	Negative	Negative	Positive	Negative
Negative	1/160	580	Positive	Positive	Positive	Positive	Negative
Negative	Negative	140	Positive	Positive	NA	Positive	Positive
Positive	1/160	Negative	NA	Positive	Positive	Positive	Positive



Sequencing eggs stool: *S. haematobium (ITS)* x *S. bovis (cox)*

Diagnosis in travellers

A Woman With Chronic Lower Abdominal Pain, Vaginal Discharge, and Infertility After a Stay in Mali

Steven Van Den Broucke, Idzi Potters, Marjan Van Esbroeck, Lieselotte Cnops, Vasiliki Siozopoulou, Cyril Hammoud, Tine Huyse, Emmanuel Bottieau

Open Forum Infectious Diseases, Volume 7, Issue 5, May 2020, ofaa133, https://doi.org/10.1093/ofid/ofaa133

Dra I PCR: +
Sm1-7 PCR: -

Sequencing rectum biopsy: *S haematobium* (cox)

Cervix snip: *S. bovis + S. haematobium* (cox) → mixed or hybrid infection (egg shape)

Diagnosis in travellers

Acute Schistosomiasis With a *Schistosoma mattheei* × *Schistosoma haematobium* Hybrid Species in a Cluster of 34 Travelers Infected in South Africa FREE

Lieselotte Cnops, Tine Huyse, Ula Maniewski, Patrick Soentjens, Emmanuel Bottieau, Marjan Van Esbroeck, Joannes Clerinx Author Notes

Clinical Infectious Diseases, Volume 72, Issue 10, 15 May 2021, Pages 1693–1698,
https://doi.org/10.1093/cid/ciaa312

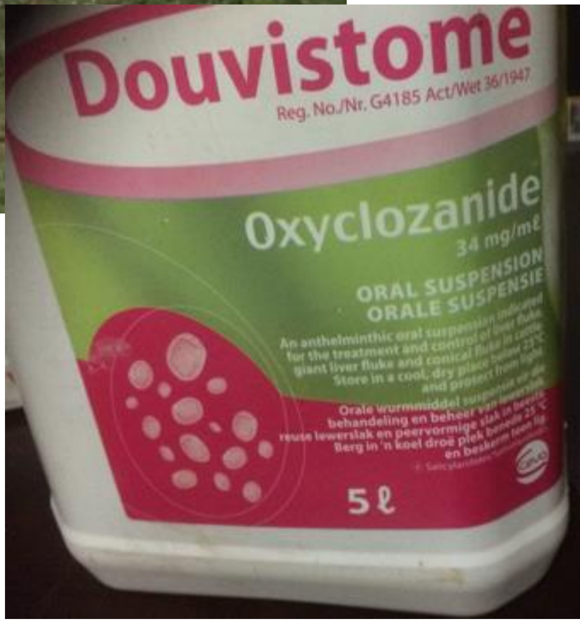
Symptom	Patients, No.
Among all patients (n = 34)	
"Swimmer's itch"	16 (47)
Any acute symptoms	32 (94)
Among patients with symptoms (n = 32)	
Fever	22 (69)
Cough	16 (50)
Abdominal pain	14 (44)
Diarrhea	5 (15)
Headache	22 (69)
Muscle ache	17 (53)

	Patients, No./Total No. (%)		
Result	Weeks 4–5	Weeks 7–8	Weeks 13–14
Eosinophil count			
>500/µL	16/33 (48)	27/34 (79)	7/34 (21)
>750/µL	12/33 (36)	22/34 (65)	3/34 (9)
>1000/µL	9/33 (27)	21/34 (62)	2/34 (6)
Positive Ab results			
ELISA	0/33 (0)	12/34 (35)	11/34 (32)
IHA	3/33 (9)	0/34[a] (0)	1/34[a] (3)
Schistosoma ova in samples			
Urine	0/33 (0)	0/34 (0)	0/34 (0)
Stool	0/31 (0)	0/27 (0)	0/28 (0)
Positive serum PCR results			
Dra1	24/33 (73)	30/34 (88)	24/34 (71)
Sm1–7	1/34 (3)	0/34 (0)	ND

Sequencing serum samples:
S. mattheei x *S. haematobium*

Inspection of site of infection (SA)

SITE	*B. africanus*		
	Inf.	Total	Prev.
Boshuisje	19	21	90.5
Beke Beke	32	37	86.5
Boekenhout	5	6	83.3
Watergat	4	4	100*
De Brug	12	14	85.7
Total	**72**	**82**	**83.7**



Story not finished yet…

Increased monitoring needed, following a One Health approach

Acknowledgements

KU LEUVEN

- Nele Boon
- Filip Volckaert
- Linda Paredis
- Tim Maes

INSTITUTE OF TROPICAL MEDICINE ANTWERP

- Katja Polman
- Lynn Meurs
- Frederik Van den Broeck
- Lot Cnops
- Patrick Soentjes
- Steven Van Den Broucke

Senegal

- Field team Richard-Toll
- Moustapha Mbow (DANTEC)
- Participants field study

vliruos SHARING MINDS, CHANGING LIVES

fwo Research Foundation Flanders Opening new horizons

A FOCUS ON MALAWI

SCHISTOSOMIASIS & A NEW ONE HEALTH

Origins of schistosome hybrids - Tine Huyse (BE)

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Malawi Liverpool Wellcome Programme

Hybridization in Urogenital Schistosomiasis (HUGS)

Janelisa Musaya PhD

HUGS

Hybridisation in Urogenital Schistosomiasis

23 November 2023

Hybridization in urogenital schistosomiasis (HUGS): A longitudinal population study highlighting transmission biology and epidemiological impact of *Schistosoma haematobium*-hybrids in Malawi intended for Mangochi and Nsanje districts

Janelisa Musaya
Associate Professor KUHES
Interim Deputy Director MLW

ECTMIH 2023 UTRECHT
SIGELEGE BEACH RESORT 20 to 23 November 2023

HUGS: WHAT IS IT ABOUT

- **Hybridisation**
- an emerging public health concern in our changing world
- Refers to pairing of male and female schistosomes of different species producing “hybrids” progeny
- Production of dominant hybrid species may result in changes of their biological characteristics
  - host selectivity,
  - Fertility
  - infectivity,
- Leading to evolution of *schistosoma* species,
  - regional distribution of the population
  - the changes of epidemic patterns,
  - and pathogenicity to human and animals,

Impact on the global schistosomiasis elimination plans

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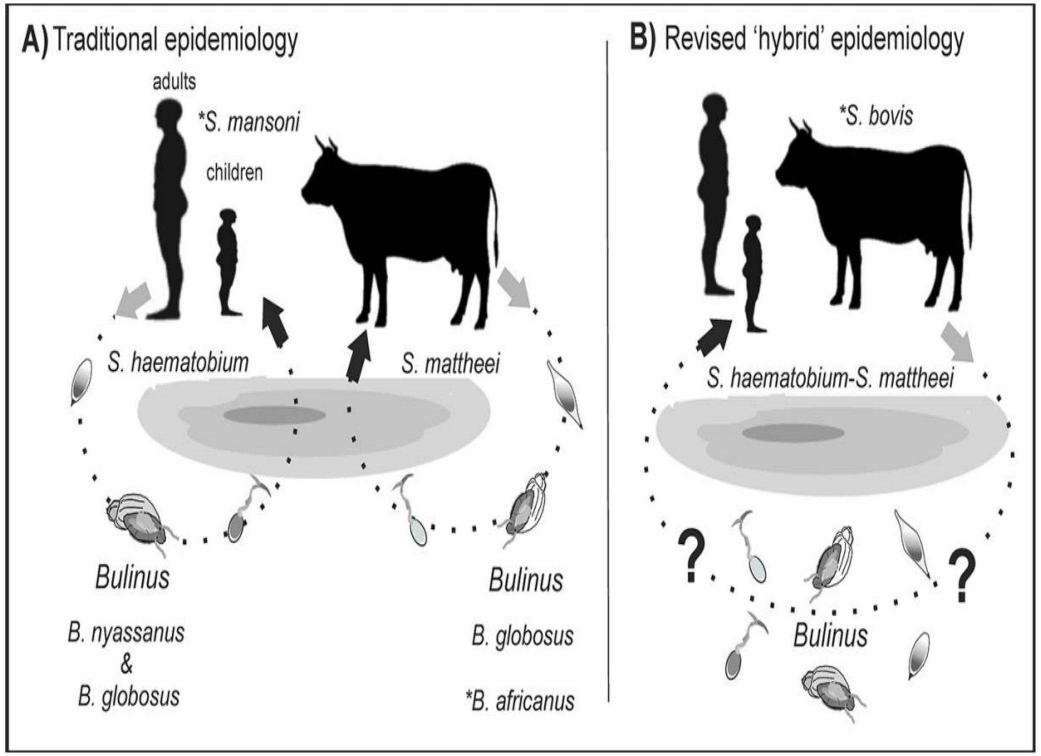
The HUGS concept on Hybridization

- **Diseases transmission**

- ✓ Can viable hybrids be transmitted zoonotically? e.g., between humans and ruminants?
- ✓ Are hybrids able to infect a wider rage of snail intermediate host species?
- ✓ Are hybrids more (or less) resistant to treatment with praziquantel?

- **Disease pathology**

- ✓ Do female hybrids produce more (or less) eggs?
- ✓ Can cause unusual egg morphology; are hybrid eggs more (or less) pathogenic?
- ✓ Role of hybrids in female & male genital schistosomiasis



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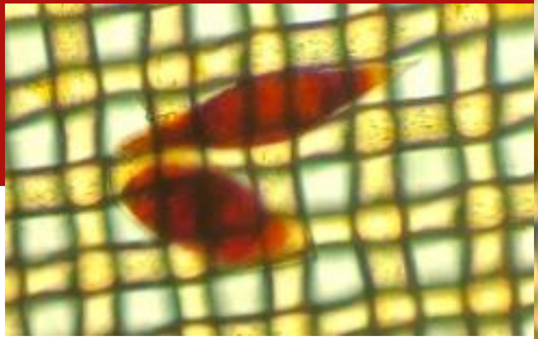
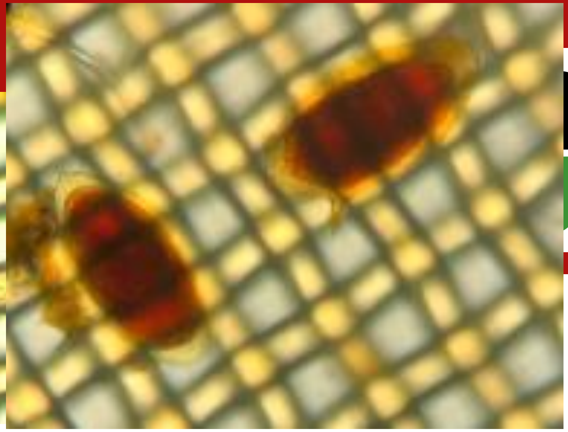
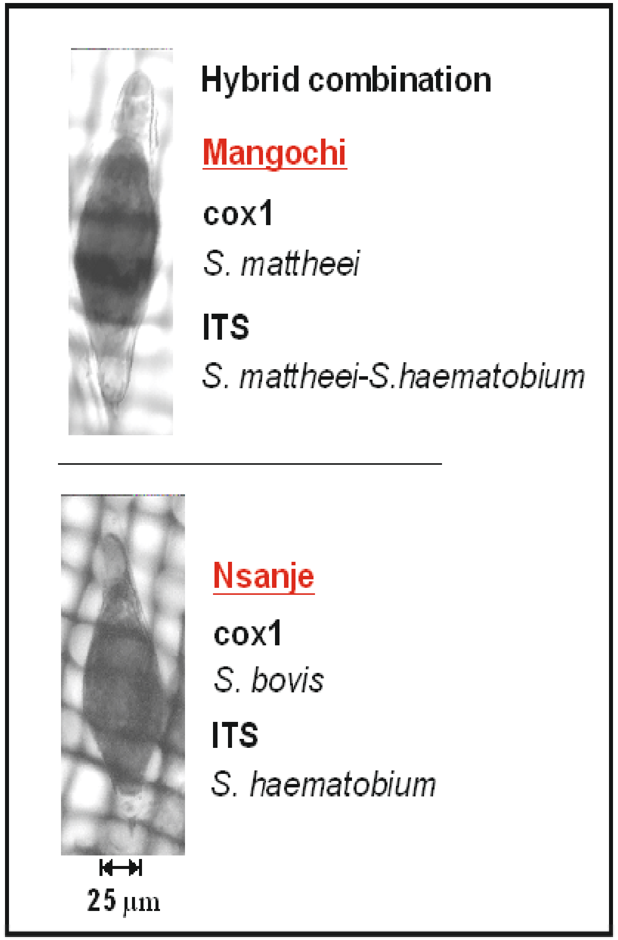
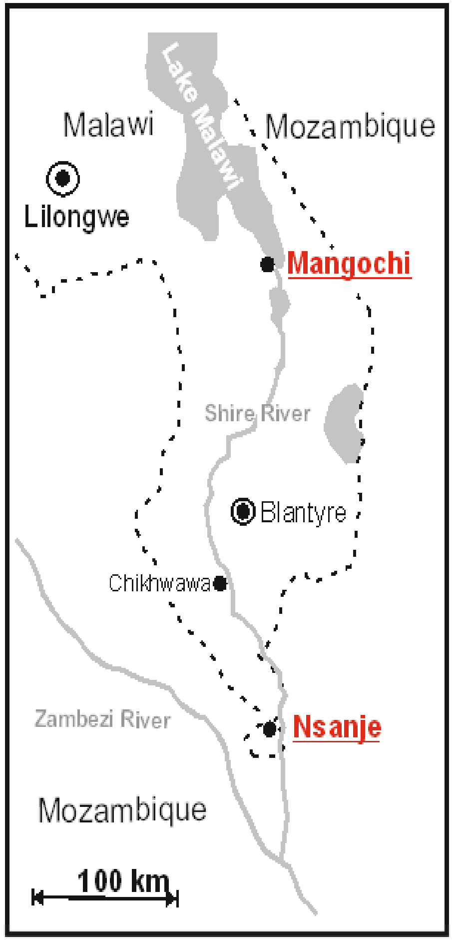
Background to HUGS





- Recent parasitological surveillance (2018) found unusual egg morphologies (school-aged children) in Mangochi and Nsanje Districts
- Genotyping found *S. mattheei* – *S. haematobium* (Mangochi) and *S. bovis* – *S. haematobium* (Nsanje) hybrids
- Mixed *S. mansoni* and *S. haematobium* *ectopic eggs in urine* (or stool ?*S. mattheei*)
- Mangochi and Nsanje Districts selected as areas for further and more detailed investigation





HUGS: 4-year Wellcome Trust/NIHR Project (from April 2021)

CO-PI: Prof Stothard and Assoc Prof Musaya

- Four-year Wellcome Trust funded Joint Investigator award
- Collaboration between Malawi-Liverpool-Wellcome Programme (MLW), Kamuzu University of Health Sciences and the Liverpool School of Tropical Medicine (LSTM)

Our Aims

- Ascertain if any altered host morbidity as measured by point-of-contact assays and portable ultrasonography
- Reveal hybrid environmental transmission upon malacological and livestock surveillance
- Verify if spatial patterns of hybrid coinfection holds or alters after praziquantel treatment in these communities through one-year longitudinal follow up study

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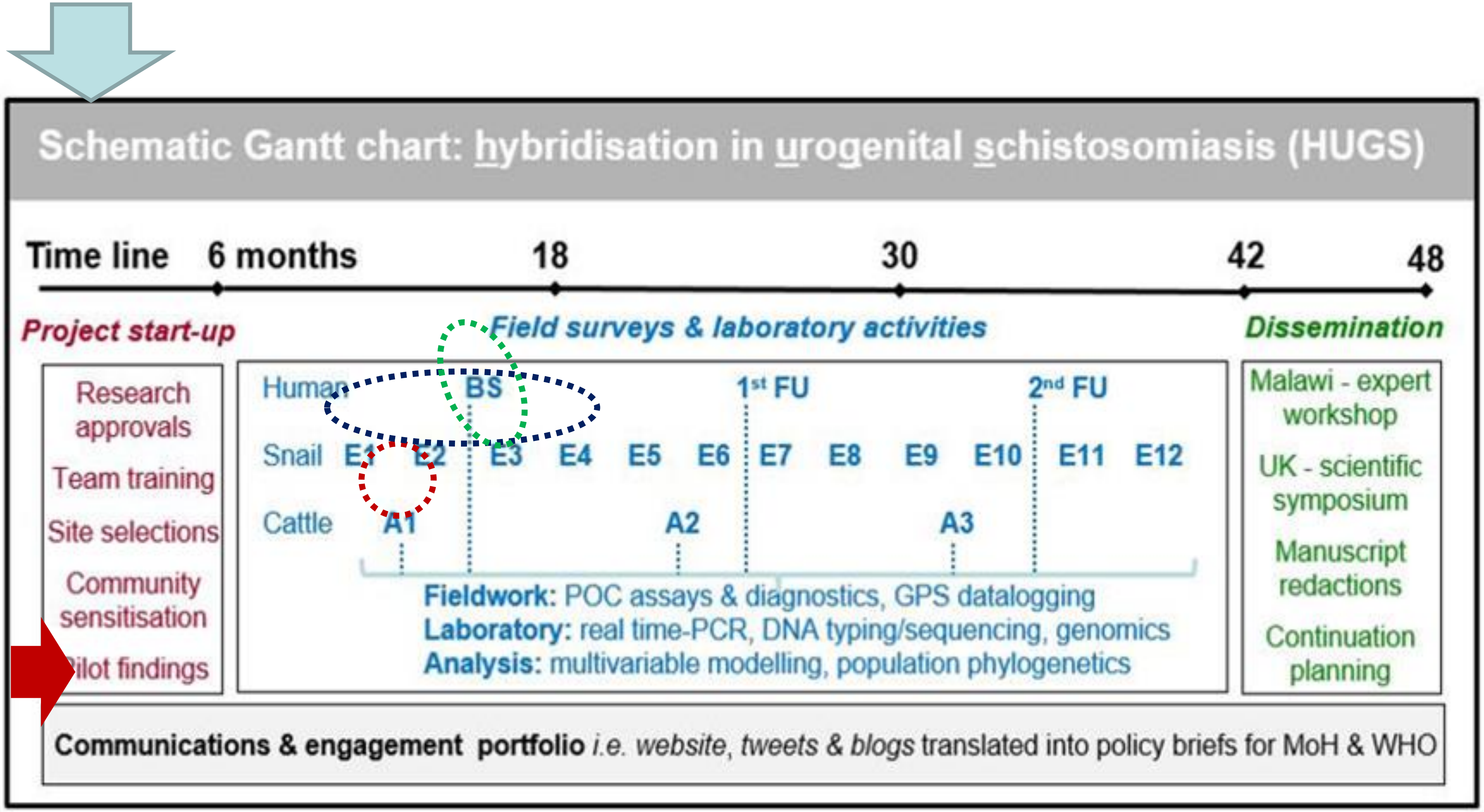
A longitudinal population study highlighting the transmission, epidemiological impact and associated host morbidity of *Schistosoma haematobium*-hybrids in Malawi



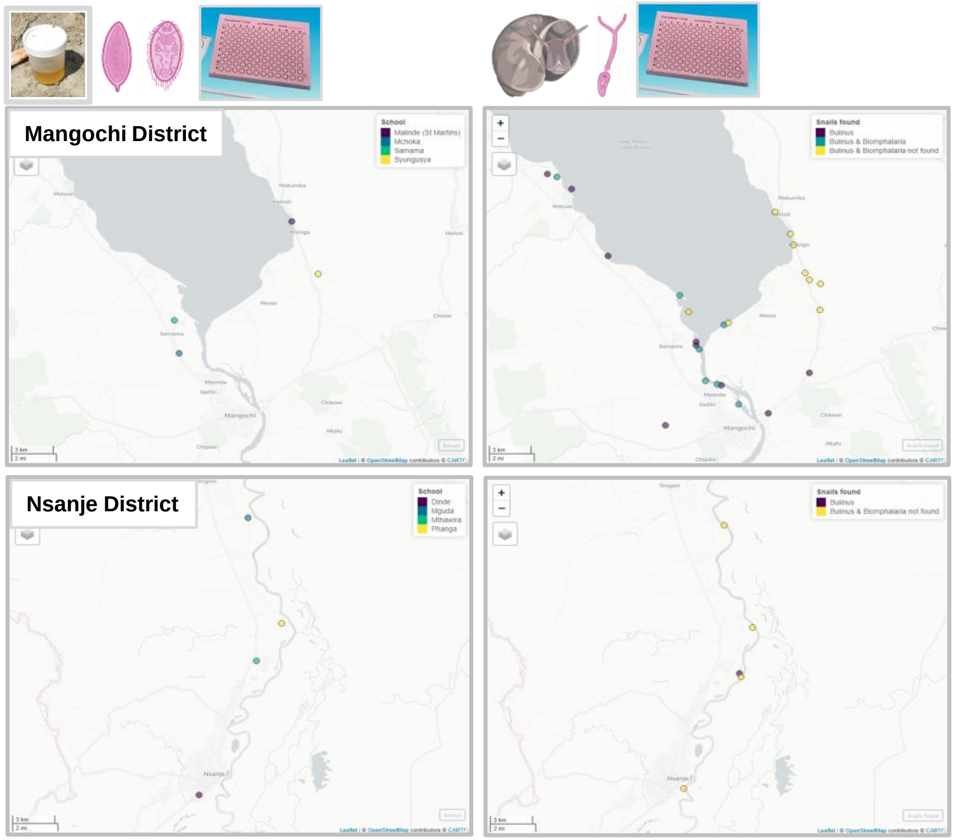
Pilot study: 2021

Mangochi District:

- Parasitological surveys across four primary schools
- 363 school-aged children
- 38% mean prevalence of infection (~20% 50+ eggs p/10 mL urine)
- Malacological surveys: Lake Malawi southern shoreline

Nsanje District:

- Parasitological surveys across four primary schools
- 94 school-aged children
- 35% mean prevalence of infection (~14% 50+ eggs p/10 mL urine)
- Malacological surveys: Shire River

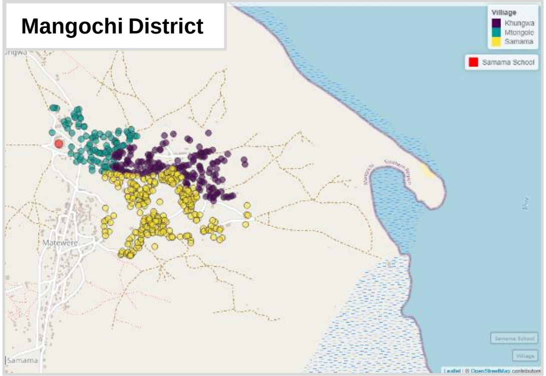


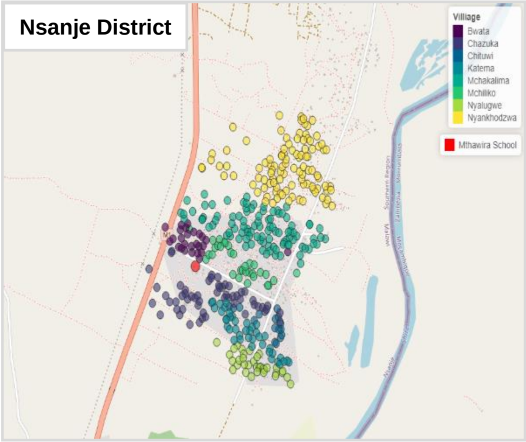
Samama in Mangochi and Nthawira in Nsanje were selected based in high prevalence

Baseline Survey: 2022

- Households selected randomly in 8 villages of Mthawira school in Nsanje district (405 households) and 3 villages of Samama school in Mangochi district (382 households) to attain a sample size of 2,400.

- Individual questionnaires administered, eliciting information on their health, education, socioeconomic status, water contact and available livestock.





Questionnaires, urine dipstick, POC-CCA, filtration and microscopy

HUGS
Hybridisation in UroGenital Schistosomiasis

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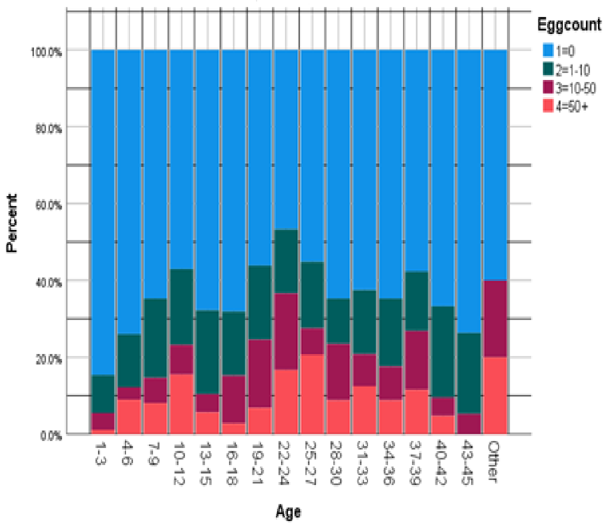
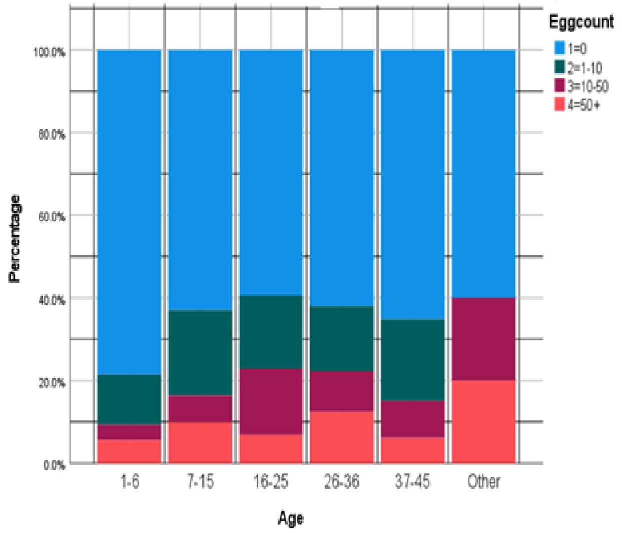
Nsanje results

Proportion of Study participants with urine *S. haematobium* eggs from Nsanje district





1050 participants recruited
348 participants (32.7%) had *S. haematobium* eggs in their urine samples
1.0% participants had positive POC-CCA indicative of possible intestinal *S. mansoni* co-infection,

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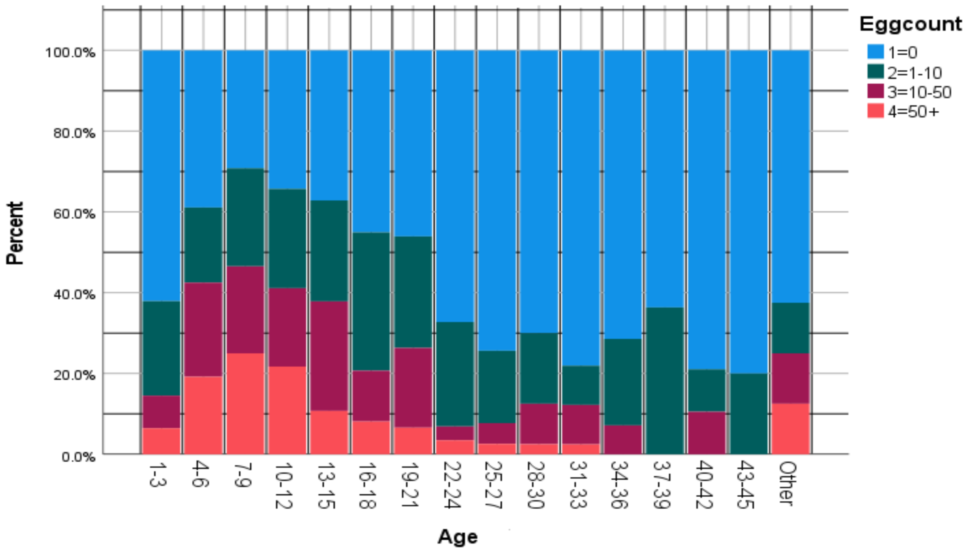
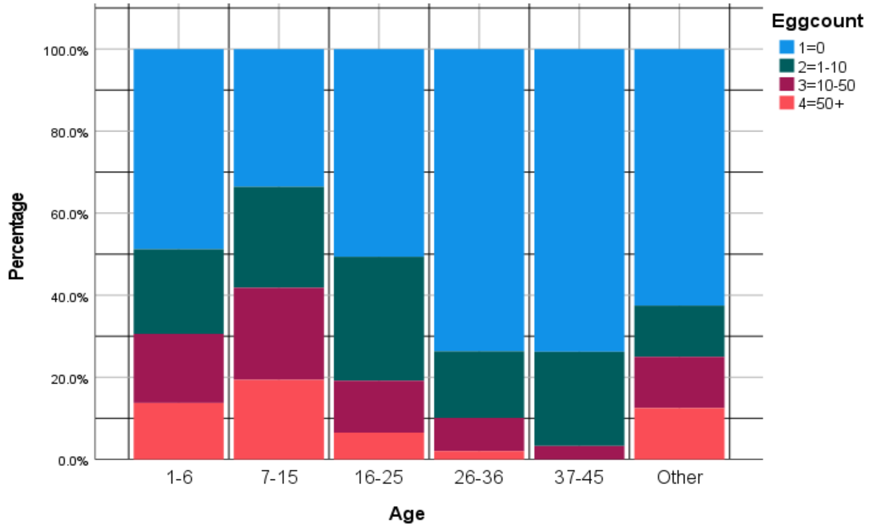
Mangochi results

Proportion of Study participants with urine *S. haematobium* eggs from Mangochi district





1228 participants recruited
617 (49.8%) had *S. haematobium* eggs in their urine samples
12.4% participants had positive POC-CCA indicative of possible intestinal *S. mansoni* co-infection,

Hybrid schistosomes

	Field		qPCR positives Ct <30		
	S.mansoni	Other/odd Schisto eggs	S.mansoni (75-76)	S.matt (70-72.3)	Other (73-75)
Nsanje	0	8	1	11	6
Mangochi	6*	5	94	50	13

8.2% participants had high infection intensity (50+ *S. haematobium* eggs) in Nsanje

16.4% participants had high infection intensity in Mangochi.

High infection intensity in Nsanje more in older children and adults, 7-15 and 26-36 years, compared to younger children in Mangochi, 1-6 and 7-15 years.

Molecular analysis indicate a proportion of 7% of the hybrid infections in the survey population.

Snail and animal contribution to hybrid story

HUGS Hybridisation in UroGenital Schistosomiasis

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Conclusion

Schistosomiasis is still present in Malawi **despite** Mass Drug Administration

Local people easily get infected during their routine household, recreational and occupation activities, many (if not all) have contact with animal watering sites

Schistosome hybrids present a new dimension in the efforts of eliminating schistosomiasis as a Public Health Problem

LSTM LIVERPOOL SCHOOL OF TROPICAL MEDICINE

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

UNIVERSITY OF LIVERPOOL

LIVERPOOL · GLASGOW · WELLCOME TRUST CENTRE FOR GLOBAL HEALTH RESEARCH

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HUGS Hybridisation in Urogenital Schistosomiasis

wellcome

Acknowledgements

HUGS-UK-Malawi team

Russell Stothard, Peter Makaula, Seke Kayuni, Alex Juhasz, Lucas Cunningham, Sam Jo
John Archer, Sarah Rollason, Amber Reed, David Lally, Gladys Namacha, Donalles Kapira, Priscilla Chammudzi

HUGS – Nsanje

HUGS - Mangochi

A FOCUS ON MALAWI

SCHISTOSOMIASIS & A NEW ONE HEALTH

Information about snails and schistosomes around Lake Malawi and Shire River

Peter Makaula

Malawi: J. Musaya, S. Kayuni, G. Namacha, D. Lally, D. Kapira, P. Chammudzi & B. Mainga
UK: R. Stothard, L. Cunningham, A. Juhasz, S. Jones, J. Archer & M. Alharbi

The 13th European Congress on Global Health (ECTMIH) 2023,
Utrecht, the Netherlands

Background

Hybridisation in UroGenital Schistosomiasis

Malawi and Schistosomiasis

- **80% of 17 million Malawians at-risk**
- ***Schistosoma haematobium* is most dominant**
- **Affects all 29 districts in the country**
- **Since 2012 annual PZQ/ALB treatments for schistosomiasis/STH**

Makaula *et al. Parasites & Vectors* 2014, **7**:570
http://www.parasitesandvectors.com/content/7/1/570

Parasites & Vectors

REVIEW Open Access

Schistosomiasis in Malawi: a systematic review

Peter Makaula[1*], John R Sadalaki[2], Adamson S Muula[2], Sekeleghe Kayuni[3], Samuel Jemu[4] and Paul Bloch[5]

Background

Hybridisation in urogenital schistosomiasis (HUGS)

A 4-year NIHR-Wellcome project to conduct a 2-year longitudinal population study highlighting the transmission, epidemiological impact and associated host morbidity of *Schistosoma haematobium*-hybrids in Malawi – One Health Approach

Background

HUGS
Hybridisation in UroGenital Schistosomiasis

One of the questions HUGS is trying to address is:

> ***"Which environmental-, ecological-or genetic-drivers diminish or enhance hybrid transmission?"***

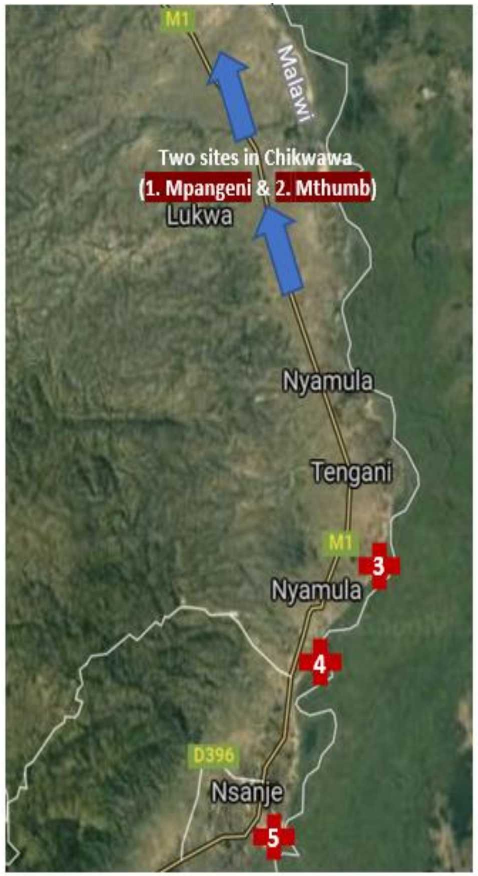
By regularly observing and collecting environmental data from selected sites, we hope to see dynamic changes of intermediate host snails through the year and ascertain whether hybrid transmission is seasonal or continuous throughout the year.

Methods

To answer this question:

We planned to conduct quarterly environmental surveys at 12 pre-determined sites

(7 in Mangochi, 2 in Chikwawa and 3 in Nsanje districts).



Methods

Seven environmental snail surveys conducted from February 2022 (E1) through September 2023 (E7)

- **Sampling** using hand-scoops for 15 minutes collecting time,
- **Recording** GPS coordinates, water quality (pH, temperature, conductivity & TDS)
- **Taking** note of any human/animal contacts & vegetation
- **Documenting** photographs of each site
- **Collected snail species** were classified as absent or present, with exact counts for *Bulinus* and *Biomphalaria* spp.

Methods

HUGS
Hybridisation in UroGenital Schistosomiasis

Methods

Hybridisation in UroGenital Schistosomiasis

The HUGS team collecting snails at Nsanje site 4, on Shire River.

Results: Water Quality

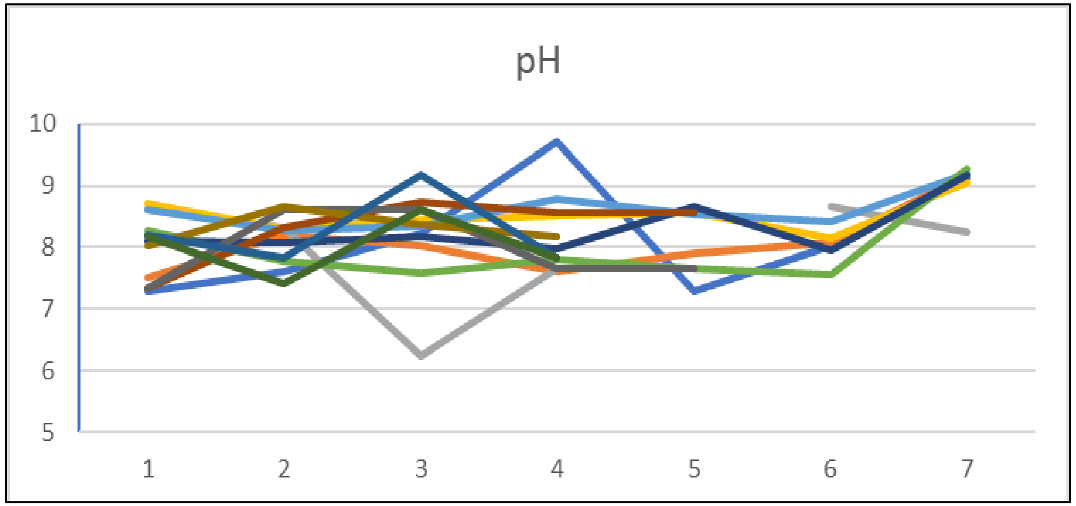
HUGS
Hybridisation in UroGenital Schistosomiasis

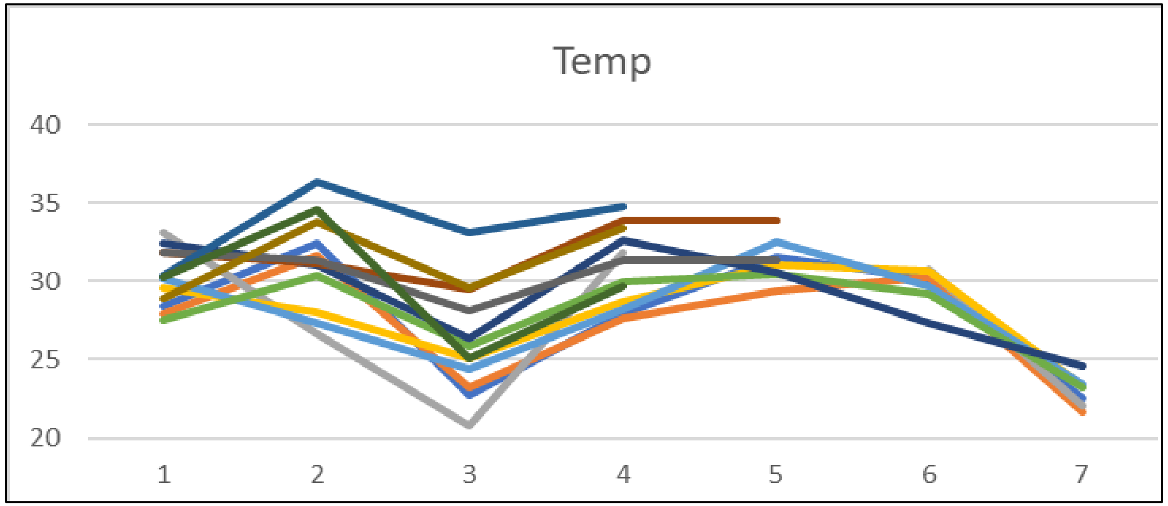
			Pilot				E2				E3			
Name	Latitude	Logitude	pH	Temp (°C)	µS	ppm	pH	Temp (°)	µS	ppm	pH	Temp (°C)	µS	ppm
Mangochi 1	14.31414	35.14407	7.3	28.45	490.5	247.5	7.6	32.45	410	207	8.22	22.7	310.5	159
Mangochi 2	14.32150	35.13140	7.5	27.9	306.5	154.5	8.185	31.65	336.5	171.5	8.03	23.2	348.5	166.5
Mangochi 3	14.36915	35.17623	8.6	33.1	290.5	146.5	8.32	26.7	291	146.5	6.235	20.8	305.66	166
Mangochi 4	14.42255	35.23224	8.7	29.6	267.5	135.5	8.3	28.05	273	138	8.45	25.1	284	142
Mangochi 5	14.45145	35.24238	8.61	30.15	272	137	8.265	27.3	278.5	139.5	8.35	24.45	304	151.5
Mangochi 6	14.47092	35.28076	8.27	27.5	285.5	144	7.785	30.35	432	150.5	7.58	25.9	650	326.5
Mangochi 7	14.44386	35.30623	8.09	32.4	1039.5	526	8.085	31.1	491.5	309	8.17	26.4	558.5	280
Boat Trip Site A	14.3518	35.27389												
Boat Trip Site B	14.40443	35.26342												
Boat Trip Site C	14.41303	35.25105												
Kingfisher														
Chikwawa 1	16.04210	34.84577	7.33	31.8	450.5	228	8.32	31.2	498	237.5	8.725	29.5	755.5	380.5
Chikwawa 2	16.09739	34.83376	7.33	31.8	450.5	228	8.6	31.35	2130.5	1078	8.6	28.15	894.5	456.5
Nsanje 3	16.85401	35.29956	8.03	28.95	804	401	8.655	33.85	273.5	129	8.36	29.6	342	172
Nsanje 4	16.88922	35.27124	8.195	30.4	289	146	7.835	36.35	268.5	134.5	9.17	33.15	352.5	181.5
Nasanje 5	16.92984	35.26588	8.165	30.3	285	144	7.405	34.6	448.5	217.5	8.6	25.05	512.5	201.5
Nsanje Port New	16.9318	35.264527												
SV-PILOT-Snail1(a)	16.10096	34.788043												
SV-PILOT-Snail1(b)	16.10096	34.788043												
SV-PILOT-Snail2	16.07910	34.81500												
Mpemba	15.89067	34.978513												

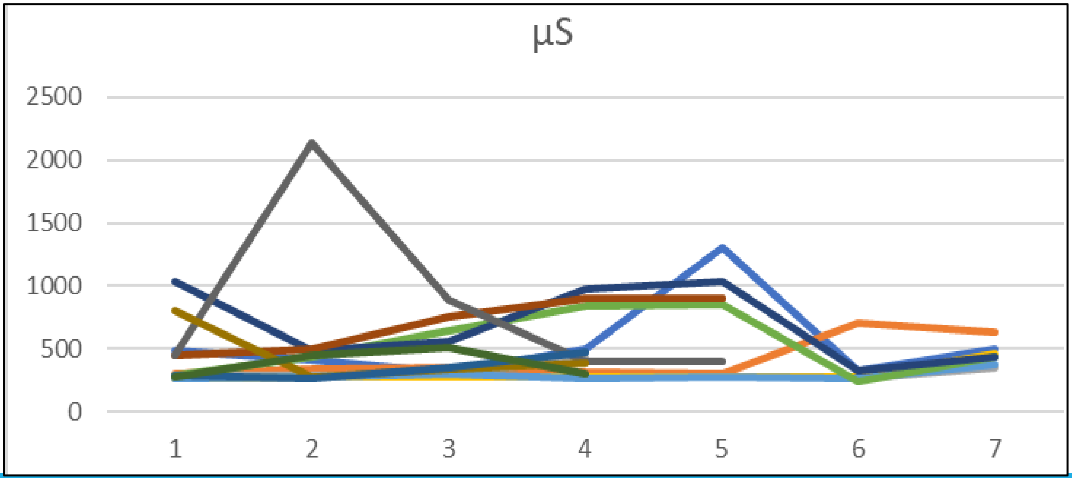
	E4				Russ Nov 22				E6				E7			
Name	pH	Temp (°C)	µS	ppm	pH	Temp (°C)	µS	ppm	pH	Temp	µS	ppm	pH	Temp	µS	ppm
Mangochi 1	9.7	27.9	496.5	248	7.29	31.6	1309.5	654.5	8.02	30.2	325	163.5	9.13	22.55	494.5	277.5
Mangochi 2	7.61	27.6	317.5	158.5	7.91	29.4	298	149.5	8.08	30.25	711.5	357	9.17	21.65	635.5	311
Mangochi 3	7.66	31.85	429.5	215.5					8.65	30.8	267	134	8.24	22.1	356.5	267
Mangochi 4	8.51	28.7	276.5	135.5	8.55	31.05	273	136	8.15	30.65	273.5	136	9.04	23.35	465	231.5
Mangochi 5	8.78	28.2	268	137.5	8.53	32.55	280.5	142	8.42	29.65	268	132.5	9.2	23.45	375	190
Mangochi 6	7.8	30	845.5	421.5	7.65	30.5	849	426	7.56	29.25	244	122.5	9.26	23.25	438.5	480.5
Mangochi 7	7.97	32.6	974	485	8.67	30.55	1035	521	7.95	27.3	322	161	9.18	24.6	443	230
Boat Trip Site A													9.27	24.95	506	411
Boat Trip Site B													9.2	24.7	510	260.6
Boat Trip Site C													9.33	24.85	415	207.5
Kingfisher													8.84	25.7	503.5	228.5
Chikwawa 1	8.55	33.95	898	454	8.56	33.95	898	454					9.66	26.35	371.5	180.5
Chikwawa 2	7.65	31.4	402.5	201.5	7.65	31.4	402.5	200					9.5	24.05	598	98.5
Nsanje 3	8.17	33.45	384.5	192									9.24	27.2	861.5	423
Nsanje 4	7.84	34.75	472	236									9	28.55	702	346
Nasanje 5	7.83	29.7	305.5	152.5									8.27	29.9	717	354
Nsanje Port New													7.76	28.8	328	161
SV-PILOT-Snail1(a)	11.12	28.3	422	211.5												
SV-PILOT-Snail1(b)	8.1	28.2	305.5	151.5												
SV-PILOT-Snail2	7.22	28.35	442	219.5												
Mpemba	8.06	26.45	329.5	165.5												

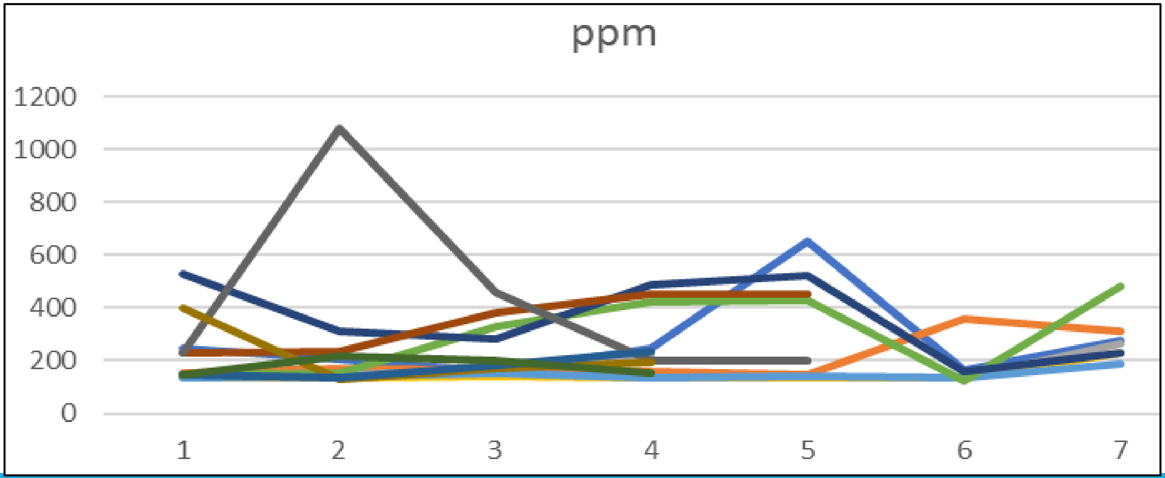
Mangochi 1 Mangochi 2 Mangochi 3 Mangochi 4
Mangochi 5 Mangochi 6 Mangochi 7 Chikwawa 1
Chikwawa 2 Nsanje 3 Nsanje 4 Nasanje 5

Results: Water Quality









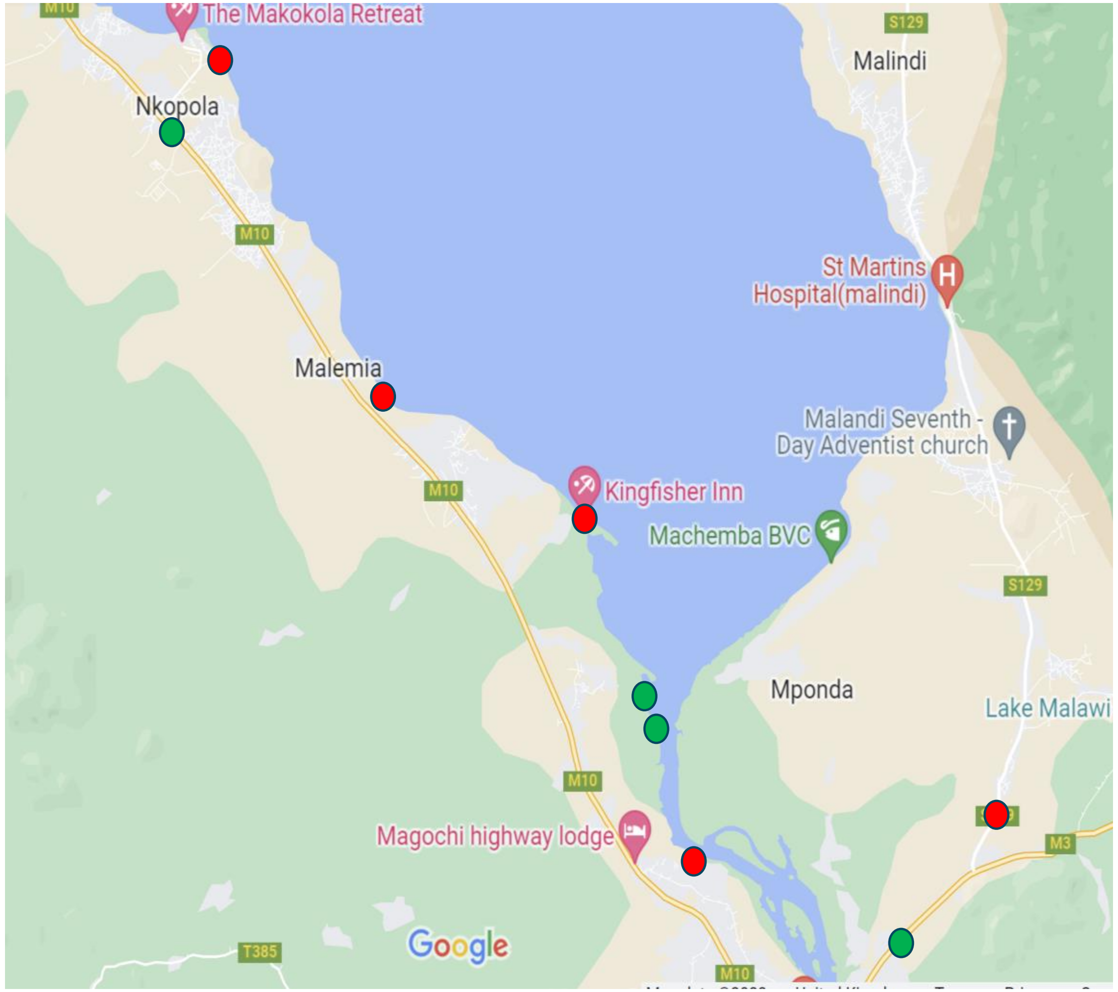
Results: Snails identified at sites *Bulinus* spp.

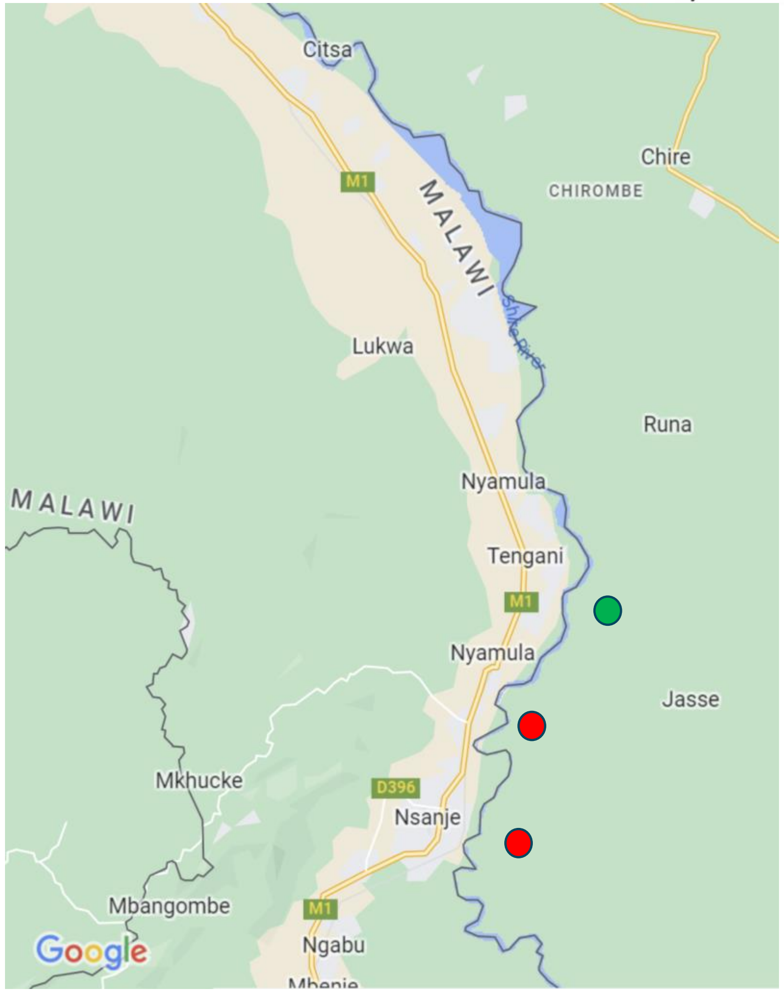
HUGS
Hybridisation in UroGenital Schistosomiasis

ID	Location	Lat	Long	Infected	Top Species	% ID	Notes
P 15D1	HUGS 24	-14.42852	35.23436	N	B. tropicus	96.57	
P 15D2	HUGS 24	-14.42853	35.23437	N	B. tropicus	97.87	
P 15D3	HUGS 24	-14.42854	35.23438	N	B. tropicus	98.2	
P 15D4	HUGS 24	-14.42855	35.23439	N	B. tropicus	98.2	
P 15D5	HUGS 24	-14.42856	35.23440	N	B. tropicus	98.03	
P 16B1	HUGS 19	14.3692	35.1762	N	B. africanus	95.26	
P 16B2	HUGS 19	14.3692	35.1762	N	B. africanus	90.53	
P 16B3	HUGS 19	14.3692	35.1762	N	B. africanus	90.83	
P 16B4	HUGS 19	14.3692	35.1762	N	B. africanus	93.84	
P 16B5	HUGS 19	14.3692	35.1762	N	B. crystallinus	88.49	
E3 AAJ7	Mangochi 3	14.3692	35.1762	N	B. africanus	95.51	
E3 AAJ10	Mangochi 3	14.3692	35.1762	N	B. africanus	95.82	
E3 AAK2	Mangochi 3	14.3692	35.1762	N	B. africanus	94.41	
E3 AAK5	Mangochi 3	14.3692	35.1762	N	B. africanus	82.89	
E3 AAK10	Mangochi 3	14.3692	35.1762	N	B. ugandae	93.31	
E3 AAL8	Mangochi 3	14.3692	35.1762	N	B. africanus	94.82	
E3 APP2	Mangochi 3	14.3692	35.1762	N	B. africanus	95.93	
E3 APP3	Mangochi 3	14.3692	35.1762	N	B. globosus	91.27	
E3 AAP6	Mangochi 3	14.3692	35.1762	N	B. africanus	96.08	
E3 ABT3	Mangochi 3	14.3692	35.1762	N	B. africanus	91.79	
E3 ABU9	Mangochi 3	14.3692	35.1762	N	B. africanus	93.26	
E4 35A	Mangochi 7	14.4439	35.3062	Y	B. globosus	99.5	
E4 35B	Mangochi 7	14.4439	35.3062	Y	B. globosus	99.02	
E4 35C	Mangochi 7	14.4439	35.3062	Y	B. globosus	98.86	
E4 35D	Mangochi 7	14.4439	35.3062	Y	B. globosus	99.17	
E4 45A	Mangochi 3	14.3692	35.1762	Y	B. globosus	71.47	
E4 45C	Mangochi 3	14.3692	35.1762	Y	B. globosus	99.01	
E4 29	Mangochi 1	14.3141	35.1441	Y			Redo
E4 32B	Mangochi 1	14.3141	35.1441	N	B. angolensis	94.83	
N22 6D	Mangochi 6	14.4709	35.2808	N	B. africanus	86.01	
N22 6E	Mangochi 6	14.4709	35.2808	N	B. globosus	93.66	
P 16F1	Mangochi 2	14.3215	35.1314	N	B. africanus	93.19	
E4 36A	Mangochi 4	14.4226	35.2322	Y	B. ugandae	92.5	
E4 43A	Mangochi 5	14.4515	35.2424	Y	B. globosus	93.74	
E4 6A	Chikwawa 1	16.0421	34.8458	N	B. africanus	96.09	
E4 1A	Chikwawa 2	16.0974	34.8338	Y	B. africanus	96.35	
E4 12A	Nsanje 3	16.854	35.2996	N	B. africanus	95.2	
E2 8A	Nsanje 4	16.8892	35.2712	Y	B. africanus	96.66	
E4 15A	Nsanje 5	16.9298	35.2659	Y	B. africanus	96.37	
AAJ7	Mangochi 3	14.3692	35.1762		B. africanus	96.39	
AAJ10	Mangochi 3	14.3692	35.1762		B. africanus	95.99	
AAK2	Mangochi 3	14.3692	35.1762		B. africanus	94.38	
AAK10	Mangochi 3	14.3692	35.1762		B. ugandae	93.67	
AAL8	Mangochi 3	14.3692	35.1762		B. africanus	94.82	

Site	B. globosus	B. africanus	B. tropicus	B. angolensis	B. ugande	B. crystallinus
Mangochi 1				X		
Mangochi 2		X				
Mangochi 3	X	X			X	X
Mangochi 4					X	
Mangochi 5	X					
Mangochi 6	X	X				
Mangochi 7	X					
Chikwawa 1		X				
Chikwawa 2		X				
Nsanje 3		X				
Nsanje 4		X				
Nsanje 5		X				

Results: Snail Screen for Schistosomes





Red= Positive
Green= Negative

Results: Snail Screen for Schistosomes

Schistosome Gen Screen: 22.1% Positive Total

Site	Infected Snail
Mangochi 1	Green
Mangochi 2	Red
Mangochi 3	Green
Mangochi 4	Red
Mangochi 5	Green
Mangochi 6	Red
Mangochi 7	Green
Chikwawa 1	Red
Chikwawa 2	Red
Nsanje 3	Red
Nsanje 4	Green
Nsanje 5	Green

Green= Positive
Red= Negative

Results: *P. columella* and *Orientogalba* sp.

	Description	Scientific Name	Max Score	Total Score	Query Cover	E value	Per. Ident	Acc. Len	Accession
☑	Pseudosuccinea columella isolate LS3 mitochondrion, complete genome	Pseudosuccine...	728	728	100%	0.0	99.26%	13757	NC_042905.1
☑	Pseudosuccinea columella isolate 6239 16S ribosomal RNA gene, partial sequence; mitochondrial	Pseudosuccine...	728	728	100%	0.0	99.26%	456	KY008512.1
☑	Pseudosuccinea columella isolate 4563 16S ribosomal RNA gene, partial sequence; mitochondrial	Pseudosuccine...	728	728	100%	0.0	99.26%	436	KY008509.1
☑	Pseudosuccinea columella isolate 5232 16S ribosomal RNA gene, partial sequence; mitochondrial	Pseudosuccine...	728	728	100%	0.0	99.26%	453	KY008508.1
☑	Pseudosuccinea columella isolate 5946 16S ribosomal RNA gene, partial sequence; mitochondrial	Pseudosuccine...	728	728	100%	0.0	99.26%	455	KY008507.1

	Description	Scientific Name	Max Score	Total Score	Query Cover	E value	Per. Ident	Acc. Len	Accession
☑	Galba pervia mitochondrion, complete genome	Galba pervia	1064	1064	100%	0.0	98.67%	13768	NC_018536.1
☑	Radix sp. clade 12 PVVO-2011 isolate 11243 cytochrome c oxidase subunit I (COI) gene, partial cds; mitoc...	Radix sp. clade ...	1064	1064	100%	0.0	98.67%	600	JN794500.1
☑	Radix sp. clade 12 PVVO-2011 isolate 9385 cytochrome c oxidase subunit I (COI) gene, partial cds; mitoch...	Radix sp. clade ...	1064	1064	100%	0.0	98.67%	600	JN794492.1
☑	Austropeplea ollula mitochondrial COX1 gene for cytochrome c oxidase subunit 1, partial cds, haplotype: A...	Austropeplea oll...	1059	1059	100%	0.0	98.50%	655	LC360956.1
☑	Austropeplea ollula mitochondrial COX1 gene for cytochrome c oxidase subunit 1, partial cds, haplotype: A...	Austropeplea oll...	1059	1059	100%	0.0	98.50%	655	LC360951.1

HUGS
Hybridisation in UroGenital Schistosomiasis

Conclusions

- *Bulinus* spp. **are widely distributed** at all 12 (100%) sites across all 3 districts.
- *Biomphalaria* spp. **are found at 4/7** (57%) **and 1/2** (50%) sites in Mangochi and Chikwawa respectively.
- Distribution and numbers of **snail species vary according to seasonal and water quality changes**.
- **Climatic and ecological changes** affect the spatial distribution of schistosomiasis snail hosts across Southern Malawi.
- Ecological changes due to **natural (cyclones)** and **artificial (irrigation)** have led to introduction of new invasive snail species.

Acknowledgements

HUGS-Malawi Team: Janelisa Musaya, Sekeleghe Kayuni, Peter Makaula, David Lally, Gladys Namacha, Donales Kapira, Priscilla Chammudzi, Bessie Ntaba & Bright Mainga.

HUGS-UK Team: Russell Stothard, Lucas Cunningham, Alexandra Juhasz, Sam Jones, John Archer, Mohammad Alharbi, Sarah Rollason & Amber Reed.

A FOCUS ON MALAWI

SCHISTOSOMIASIS & A NEW ONE HEALTH

Origins of schistosome hybrids - Tine Huyse (BE)

HUGS human studies - Janelisa Musaya (MALW)

HUGS snail studies - Peter Makaula (MALW)

***HUGS* cattle studies - Alexandra Juhasz (HU/UK)**

GPS livestock tracking methods - Julianne Meisner (UK/USA)

At the 13th European Congress on Global Health (ECTMIH) 2023, Utrecht, the Netherlands

Bovine schistosomiasis in Malawi: Some public health implications

Alexandra Juhasz

UK: R. Stothard, L. Cunningham, S. Jones, M. Al-Harbi, J. Archer

Malawi: J. Musaya, S. Kayuni, P. Makaula, L. Juziwelo

USA: E. Seto, L. Song

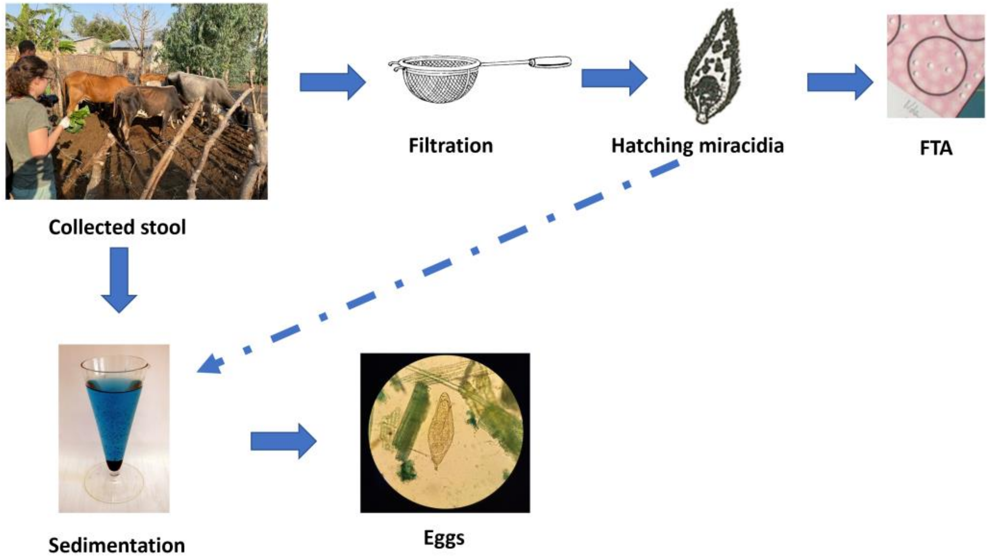
Background

4- year HUGS project at LSTM & MLW

- Focus on bovine schistosomiasis**: neglected surveillance**
- Finding ‘needles in haystacks’**: GPS micro-epidemiology**
- Schistosome ‘needles’ in public health**: emergent variants**

WHO concerns – what’s the ‘best’ bovine diagnostic?

Collection of miracidia and eggs of schistosomes

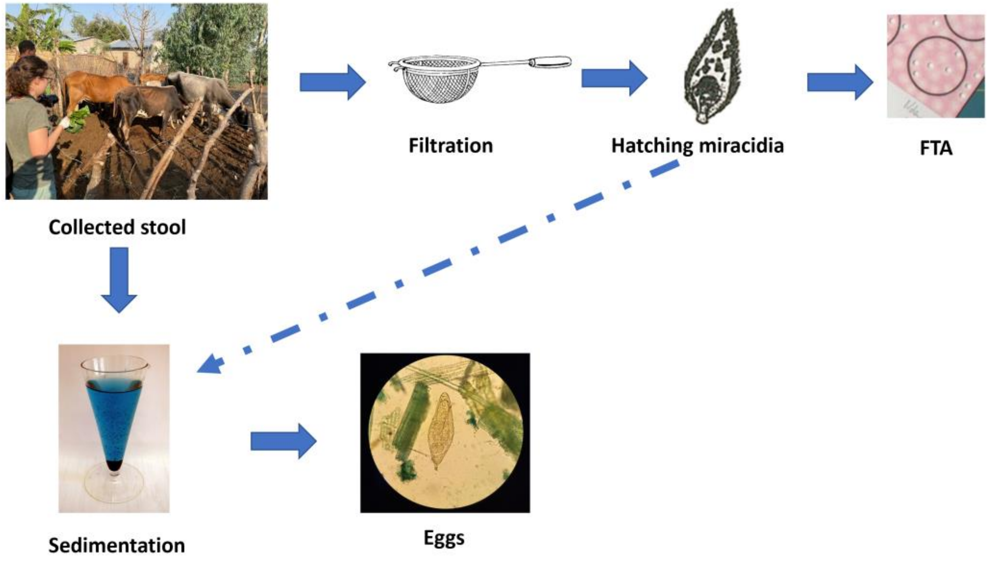


Filtration using specific nylon meshes

Miracidial Hatch Test (MHT)

WHO concerns – what's the 'best' bovine diagnostic?

Collection of miracidia and eggs of schistosomes



Filtration using specific nylon meshes

Miracidial Hatch Test (MHT)

An application in bovine schistosomiasis

First formal survey using faecal and carcass inspection

carcass (viscera)

adult worms

miracidia

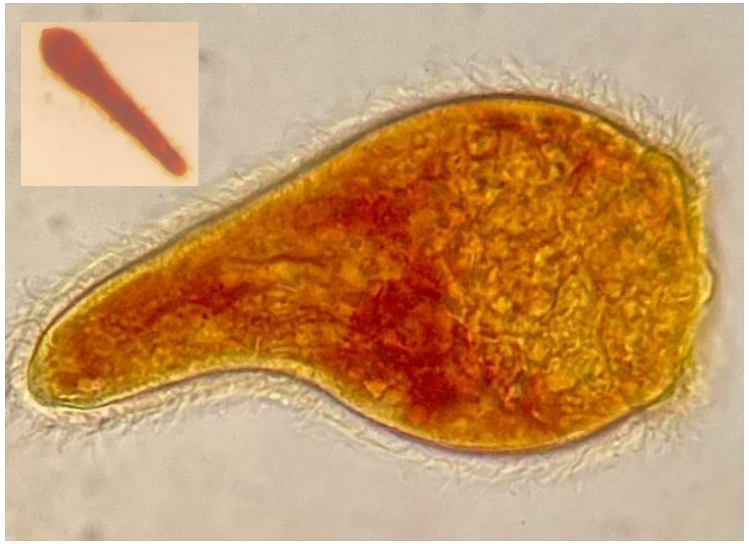
location unknown

faecal (15g)

adult worms

miracidia

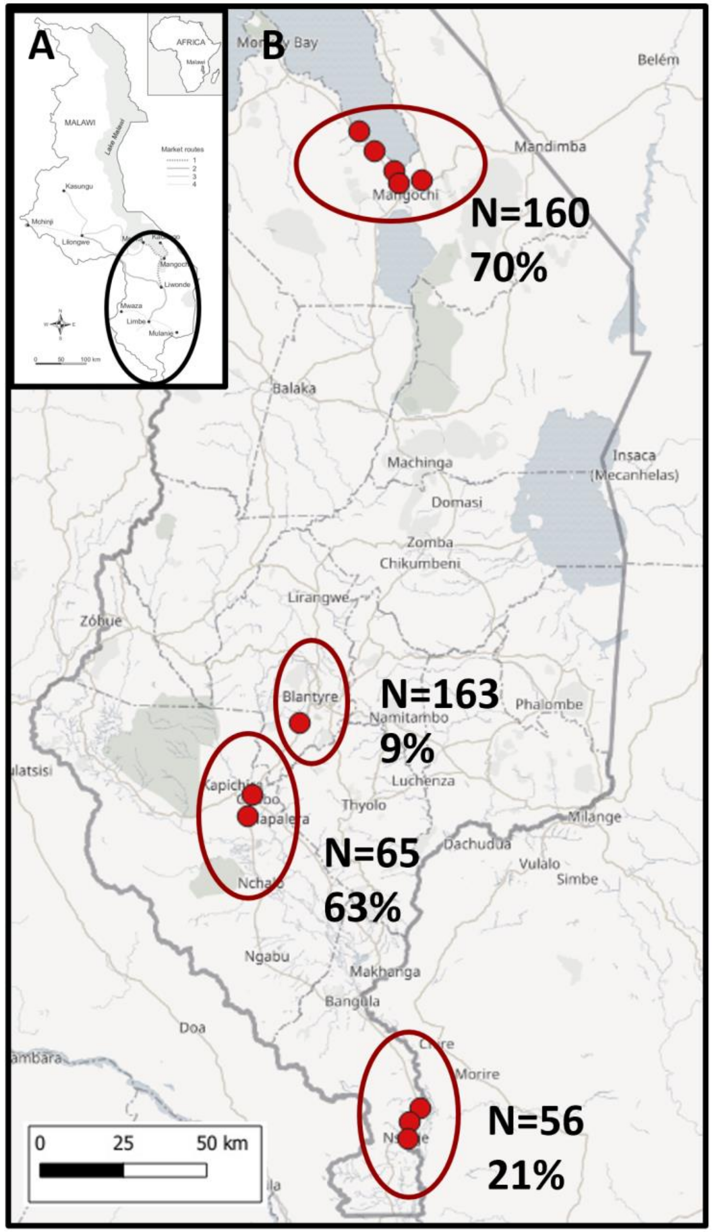
location known



HUGS – Hybridisation in Urogenital Schistosomiasis

4-year Wellcome Trust/NIHR project from April 2021

Bovine schistosomiasis is quite common



Overall prevalence

faecal sampling

Mangochi **~70%** (n=160)*

Chikwawa~**63%** (n=65)

Nsanje **~21%** (n=56)

carcass sampling (NB a 'central' facility)

Blantyre **~9%** (n=163)

* Significant variation between populations, with major differences in local snail fauna

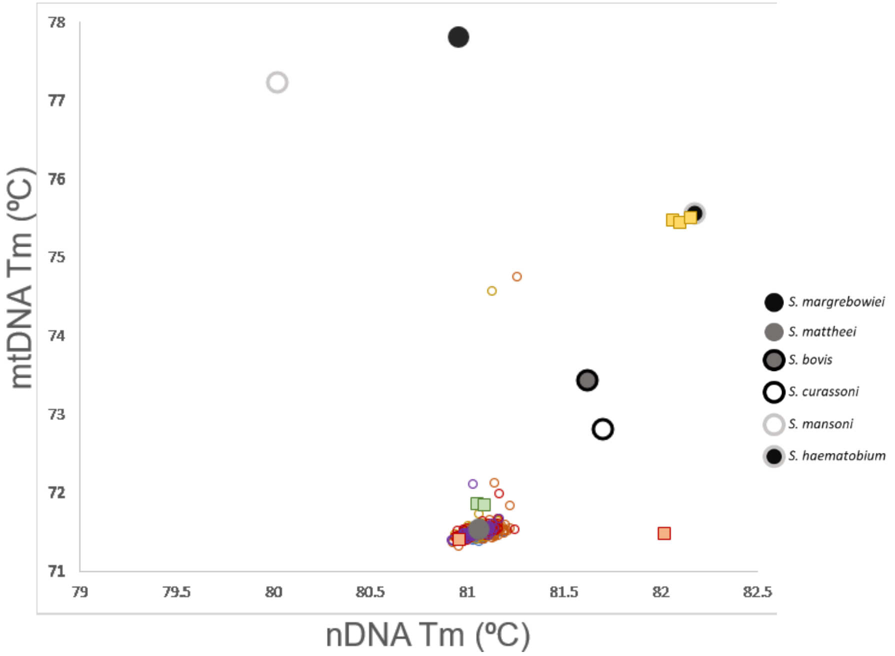
Finding schistosome ‘needles’ in haystacks – HRM genotyping

Screening miracidia (n=X)

HRM mt-r16S and nuc-rITS assays

Tm of products are ‘specific’

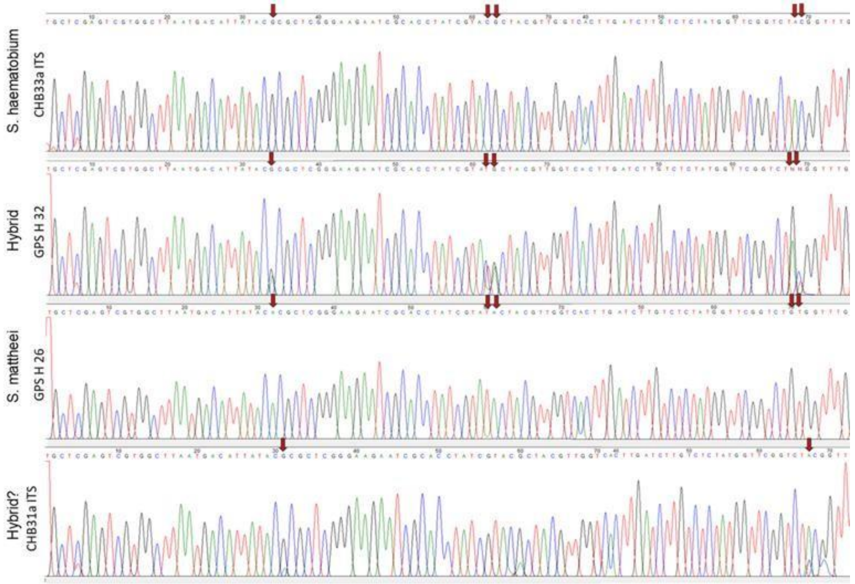
Reference & test samples overlaid



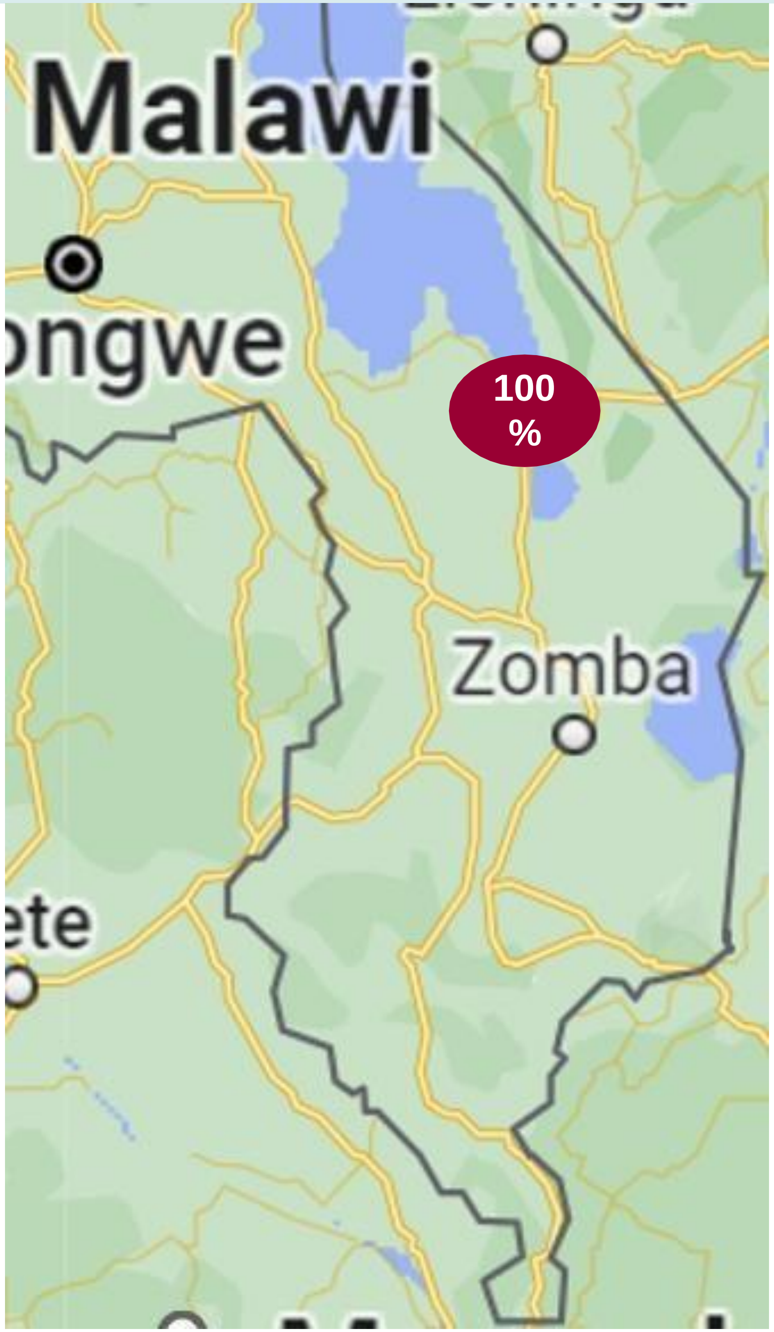
DNA sequencing

Sequence identify (*cox*1 & rITS)

‘Heterozygote’ peaks = X gen hybrids



GPS-tracking a local infected herd



2-weeks prior GPS data then

PZQ treatment (@40 mg/kg, 18th April) with later parasitological follow-ups

1-, **4-**, **6-**, **8- & 12-**weeks…monthly (**NB** intensity)

New GPS units with ‘online’ real-time reporting

https://www.techsilver.co.uk/

dementia care technologies

~ £ 180 per unit

X4 AAA batteries

~ £ 10 per month (GPS every 5 mins)

8 units purchased

New GPS units with ‘online’ real-time reporting

https://www.amazon.co.uk/

collars and cradles for units

A fraction of the cost of GPS

precision farming methods

…but would it work in Malawi?

New GPS units with ‘online’ real-time reporting

…needs a little tailoring and setting up in the right animals

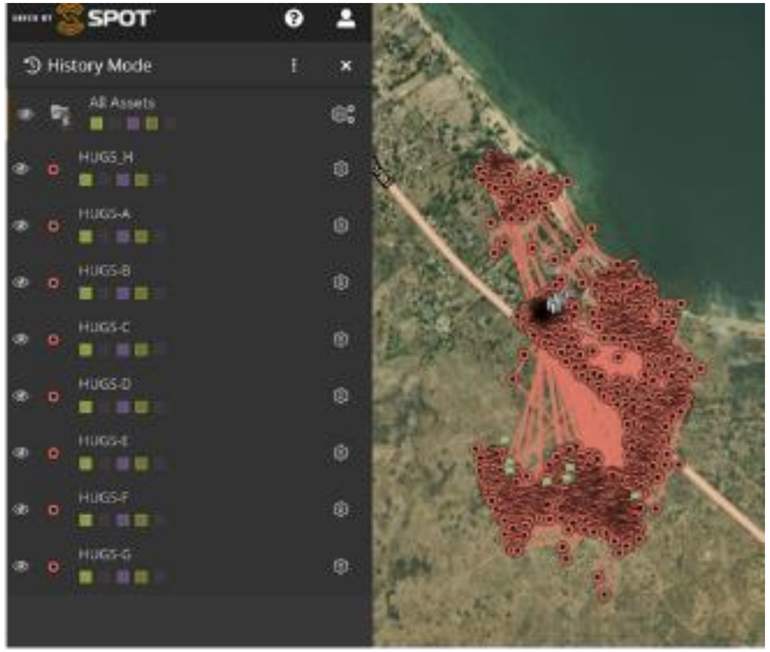
and we embedded this technology within a broader study of cattle

an 8-animal herd identified, with an adult that calved during the study,

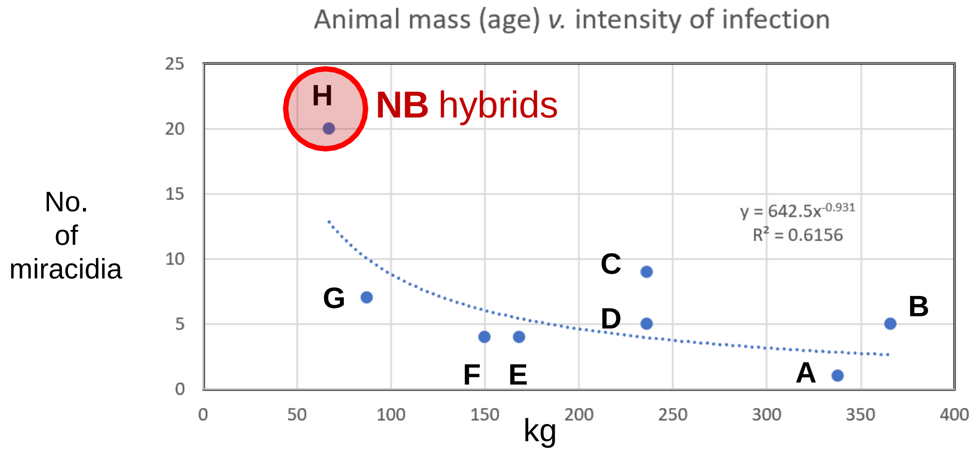
animal movements quantified within a pilot efficacy of PZQ spot-check

GPS-tracking a local infected herd – *paint is best*

Cattle GPS study is still ongoing



We have had to change ~500 batteries in total, weekly replenishment

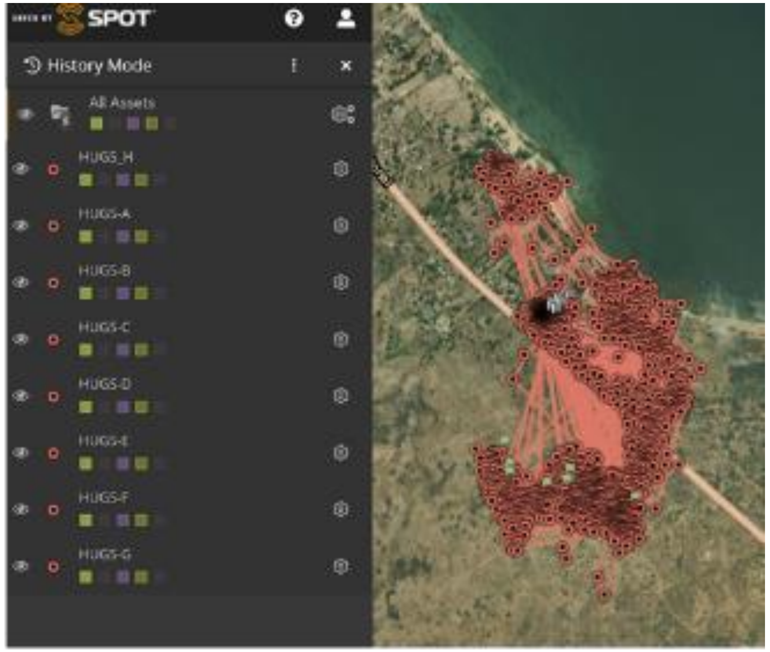


baseline

- G & H were born in Nov. & Dec 21
- ‘*New*’ infections **? more fecund**
- ‘*Old*’ infections **? less fecund**

GPS-tracking a local infected herd

Cattle GPS study is still ongoing



We have had to change ~500 batteries in total, weekly replenishment

Prev. at: 0-week = **100.0%**
1-week = **0.0%**
4-week = **0.0%**
6-week = **12.5%**
8-week = **75.0%**

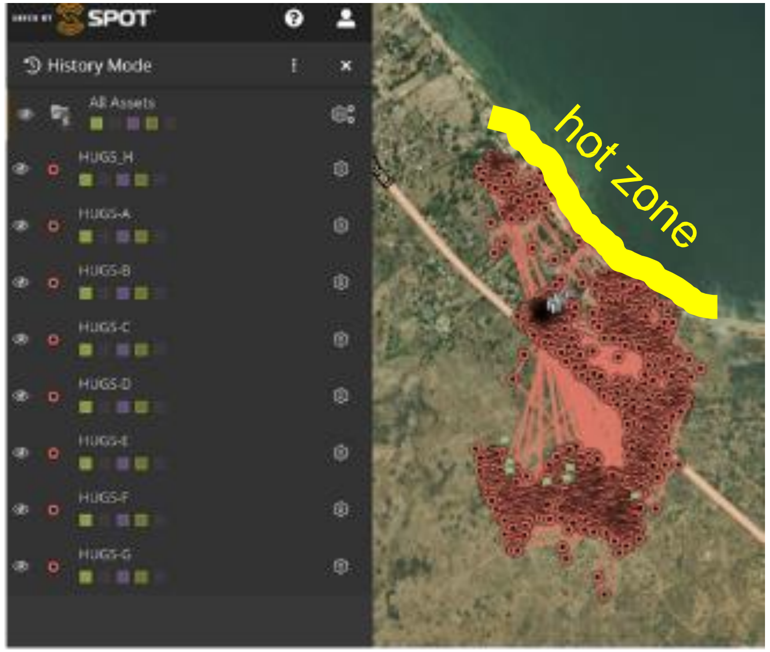
Cattle behaviour (NB ***daily herding*****)**

Regular patterning of water contact
Shedding snails found within zoning

NB: New-born calf +ve at 8 weeks

GPS-tracking a local infected herd

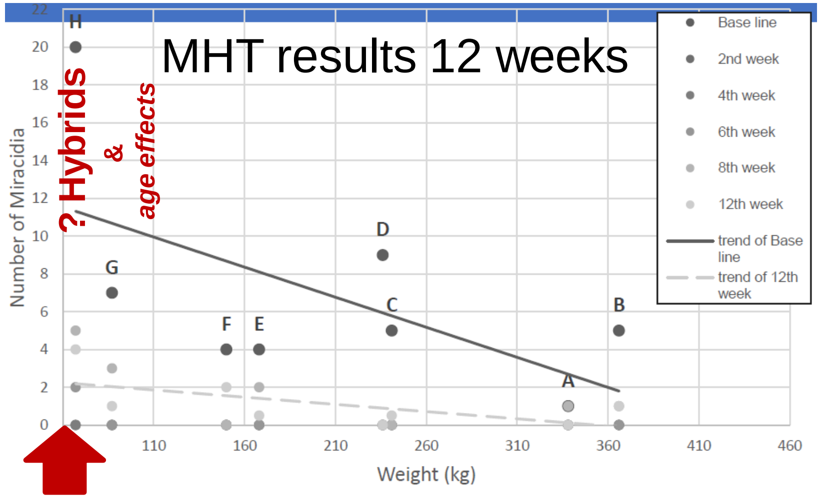
Cattle GPS study is still ongoing



Water contact: mixed effects Poisson regression model

```
Fixed effects:
                          Estimate Std. Error z value Pr(>|z|)
(Intercept)               -2.46707    0.11744 -21.007  <2e-16 ***
age                       -0.02494    0.02261  -1.103   0.270
sexM                      -0.06874    0.13039  -0.527   0.598
datetime_local_month05 -0.52781    0.04630 -11.401  <2e-16 ***
datetime_local_month06 -1.40289    0.06787 -20.672  <2e-16 ***
datetime_local_month07 -2.15426    0.12819 -16.805  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

General exposure seems to **decrease** May > July



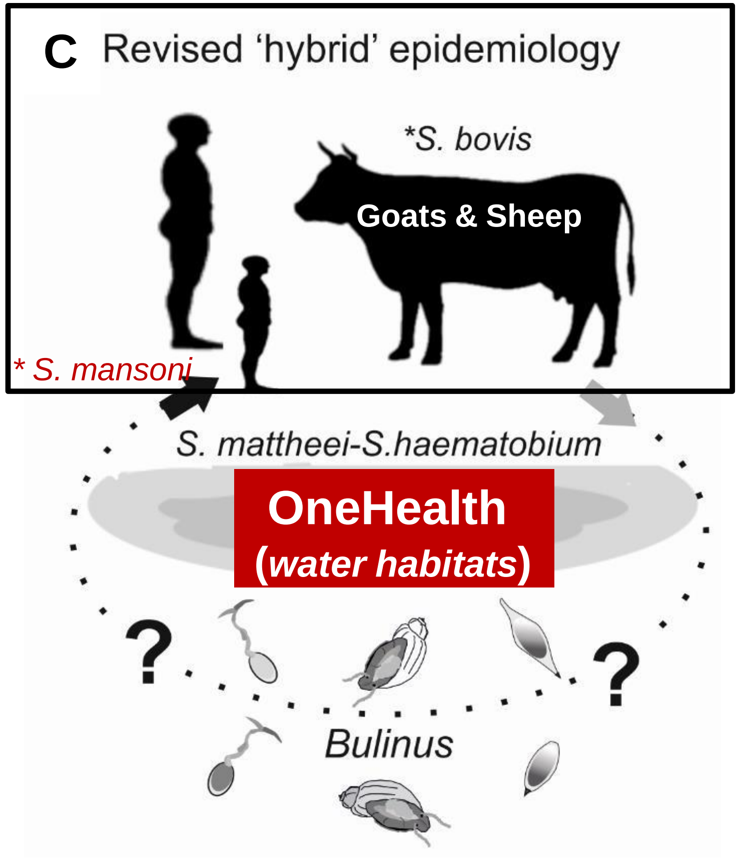
GPS-tracking a local infected herd

A typical day for these cattle GPS

Watering/crossing

Grazing/housing

Bovine schistosomiasis and public health in Malawi



Pointe

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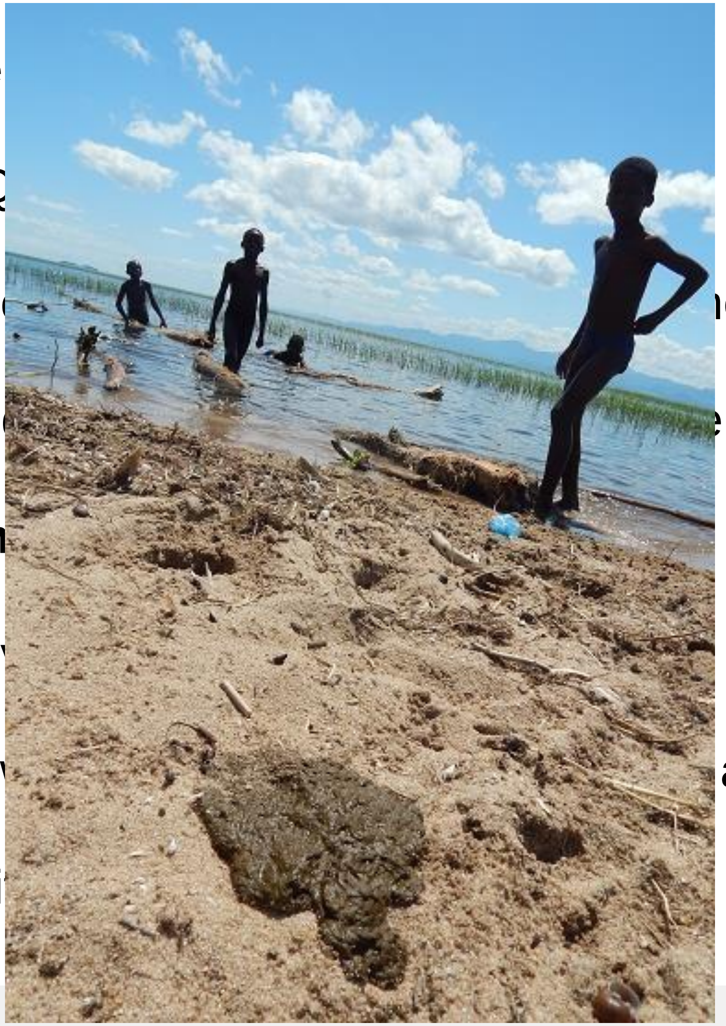

Public Health

Hybrids in cattle are **'rare'** but cattle infection with '***S. haematobium***' itself is not.

Hybrids in people are not **'rare'**, so are '**people**' or '**cattle**' the major **to-snail** source?

Acknowledgements

HUGS-UK-Malawi team

Russell Stothard, Lucas Cunningham, Sam Jones, John Archer, Sarah Rollason, Amber Reed, David Lally, Gladys Namacha, Donalles Kapira, Priscilla Chammudzi

HUGS-Nsanje

HUGS-Mangochi

Janelisa Musaya, Seke Kayuni & Peter Makaula

HUGS – Hybridisation in Urogenital Schistosomiasis

4-year Wellcome Trust/NIHR project from April 2021

Formal communications

HUGS communications

Project website with twitter & news feeds

Twitter account

A FOCUS ON MALAWI

SCHISTOSOMIASIS & A NEW ONE HEALTH

Origins of schistosome hybrids - Tine Huyse (BE)

HUGS human studies - Janelisa Musaya (MALW)

HUGS snail studies - Peter Makaula (MALW)

HUGS cattle studies - Alexandra Juhasz (HU/UK)

GPS livestock tracking methods - Julianne Meisner (UK/USA) ***Russ Stothard***

Julianne Meisner & Ed Seto

On modern GPS tracking methods for livestock

DEPARTMENT OF GLOBAL HEALTH
SCHOOL OF MEDICINE
SCHOOL OF PUBLIC HEALTH
UNIVERSITY of WASHINGTON

Center for One Health Research

meisnerj@uw.edu

Our first use of GPS-datalogging in 2006 – ‘dumb’ datalogging

Geospatial Health 7(1), 2012, pp. 1-13

Patterns of intestinal schistosomiasis among mothers and young children from Lake Albert, Uganda: water contact and social networks inferred from wearable global positioning system dataloggers

Edmund Y. W. Seto[1], José C. Sousa-Figueiredo[2,3], Martha Betson[2], Chris Byalero[4,*], Narcis B. Kabatereine[4], J. Russell Stothard[2]

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circa 2008 http://www.i-gotu.com/

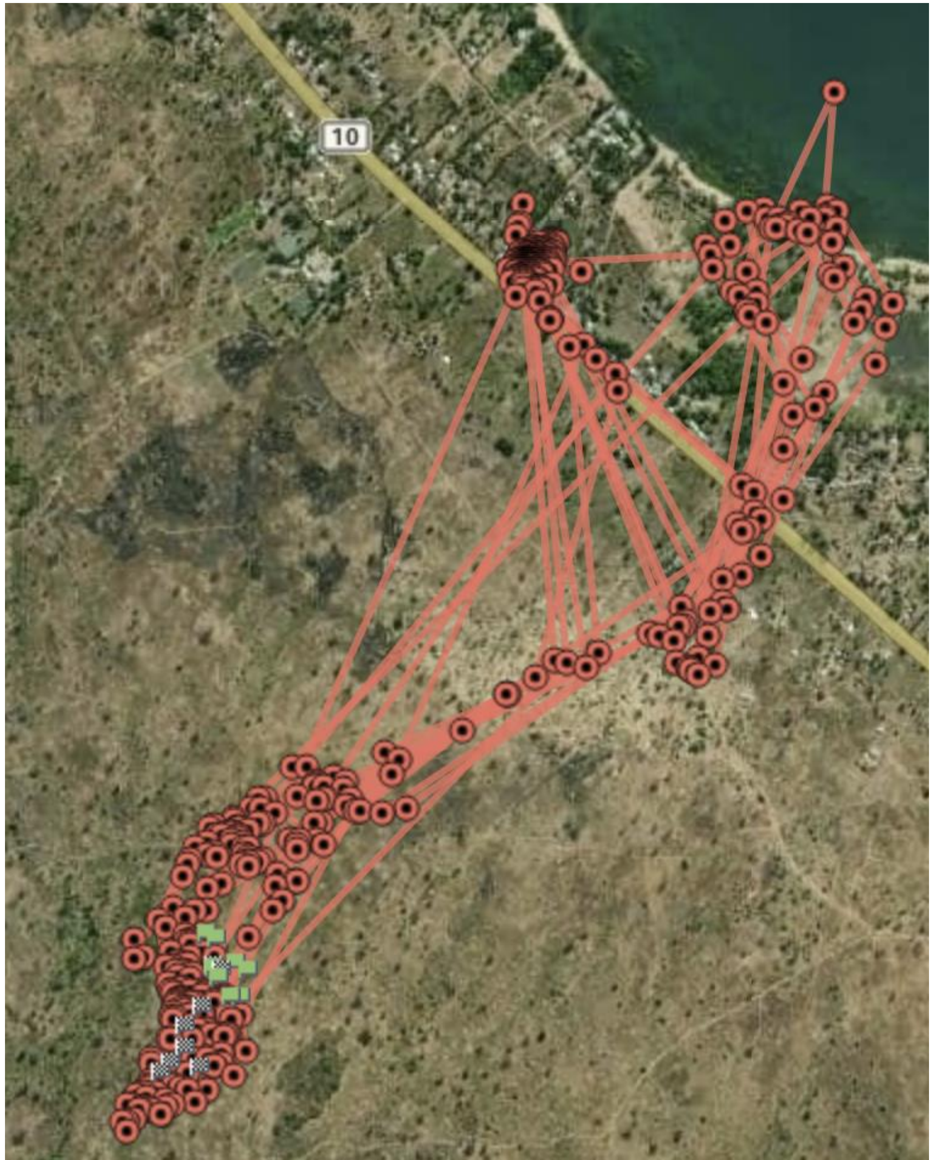
~ £ 50 per unit (*2022 out-of-stock*)

Velcro elastic harness
(mums & PSAC)

waterproofing
(plastic bag)

How much water contact does each mum and child pair have?

Why livestock GPS tracking?



‘classic’ spatial epidemiology

- Estimating exposure risk (zoonosis)

‘better’ animal production

- Precision farming
- Livestock security
- Data for network modeling

But which GPS technology to use now?

Recent "explosion" in available GPS trackers

- Purpose-built for livestock
- Wildlife tracking
- Asset tracking
- Other consumer-intended purpose

***To be** or **not to be** online?*

But which GPS technology to use now?

Network coverage: GSM vs. satellite as well as app +/- onboard storage

Intended use	Cost	Durability	Weight	Battery life	Data richness
Livestock	$$	High	Medium	Varies	High
Wildlife	$$$$	High	Higher	Extremely high	High
Assets	$	Medium	Low	High	Low
Consumer use	$	Low	Low	Generally low	Low

NB A diagnostic analogy with ***RE-ASSURED***

Study 1: Human-animal contact networks, Kenya

- Study goal: capture human-animal contact network data using GPS trackers, surveys, and daily diaries

- Piloted three devices built for livestock
  - Cattle, camels, sheep, goats, and donkeys
  - 48 devices

- March – July 2023

- Three communities:
  - Rendille (agropastoralist)
  - Borana (pastoralist)
  - Gabra (pastoralist)

Study 1: Human-animal contact networks, Kenya

3 collar Types

pro & con

FindMy	DigitAnimal	Farm Ranger
Origin: Norway Battery life: 2000+ messages Rechargeable battery: No Subscription: Per message	Origin: Spain Battery life: 1-1.5 years (satellite), 6-7 months (mobile network) Rechargeable battery: No Subscription: First year included	Origin: South Africa Battery life: 3-6 months depending on settings Rechargeable battery: Yes Subscription: Billed monthly
		

Study 1: Human-animal contact networks, Kenya

3 collar Types

pro & con

FindMy	DigitAnimal	Farm Ranger
<u>Accuracy:</u> 19.19 meters <u>Precision:</u> 6.51 meters <u>Fix rate success:</u> 41% (app), 83% (on-board storage) <u>Battery life:</u> Matched specs (still going!) <u>Community acceptance:</u> Good 	<u>Accuracy:</u> 67 meters <u>Precision:</u> 94 meters <u>Fix rate success:</u> 64% <u>Battery life:</u> Just under 6 months <u>Community acceptance:</u> Low (counterweight) 	<u>Accuracy:</u> 22.7 meters <u>Precision:</u> 15.23 meters <u>Fix rate success:</u> 74.7% <u>Battery life:</u> Just under 4 weeks <u>Community acceptance:</u> Very enthusiastic! 

Study 2: HUGS in Malawi GPS tracking

- Study goal: estimate cattle/**goat water** contact points and immersion times along Lake Malawi shoreline to quantify transmission of schistosomiasis

- Device: UK dementia care technology
  - + nylon collar with cradle and moisture-wicking material
  - Fixes every 5 minutes when the wearer is moving
  - Lightweight
  - AAA batteries (replace per week)

- May – July 2022: 8 cattle tracked

- **Aug – Oct 2022: 8 goats tracked**

Study 2: HUGS in Malawi GPS tracking

- Goat movement is very different to cattle, e.g. less need for watering

- Beneficial impact of PZQ very obvious but with different cost-impacts

Two examples of GPS livestock tracking

Define the spatial question – its scale and timeframe

- Invest in suitable hardware, staff training and community engagement

NB even an adequate GPS recorder can give a quality answer

Thank you

QnA session for speakers chaired by Lisette van Lieshout

A FOCUS ON MALAWI

SCHISTOSOMIASIS & A NEW ONE HEALTH

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