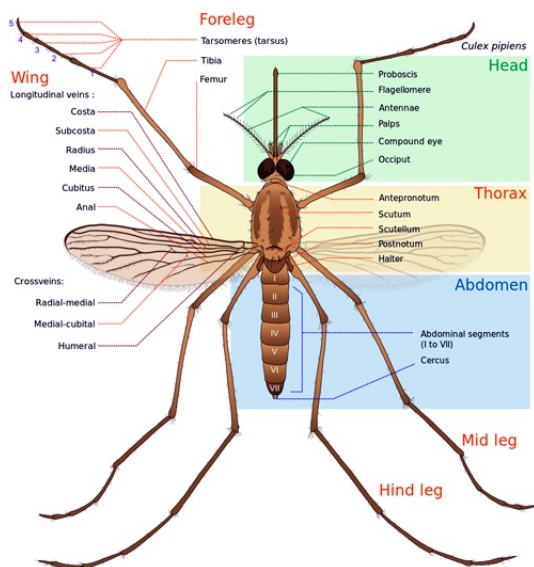


The buzz of AI: *developing bioacoustic models for challenging real-world environments*

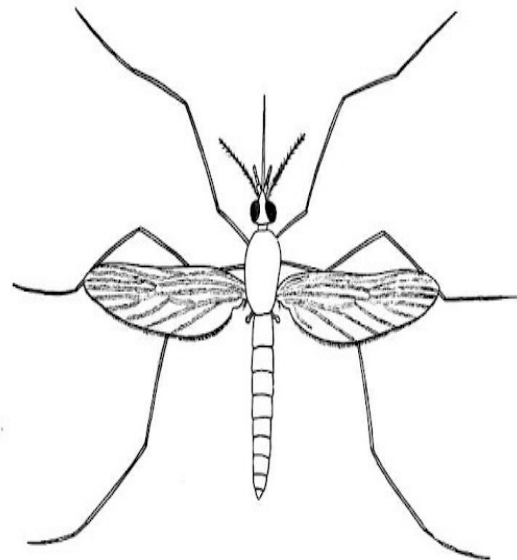
Steve Roberts

1

Biologist



Physicist



2

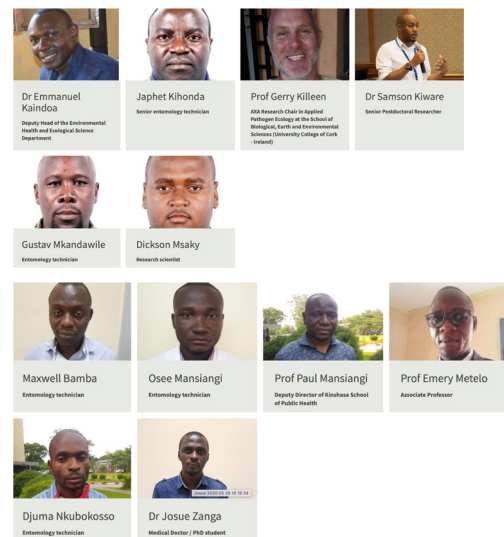
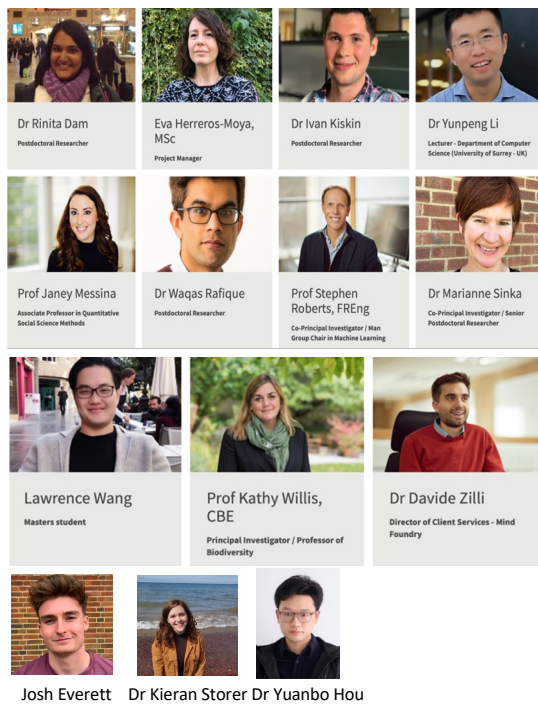
The HumBug Project (www.humbug.ox.ac.uk)



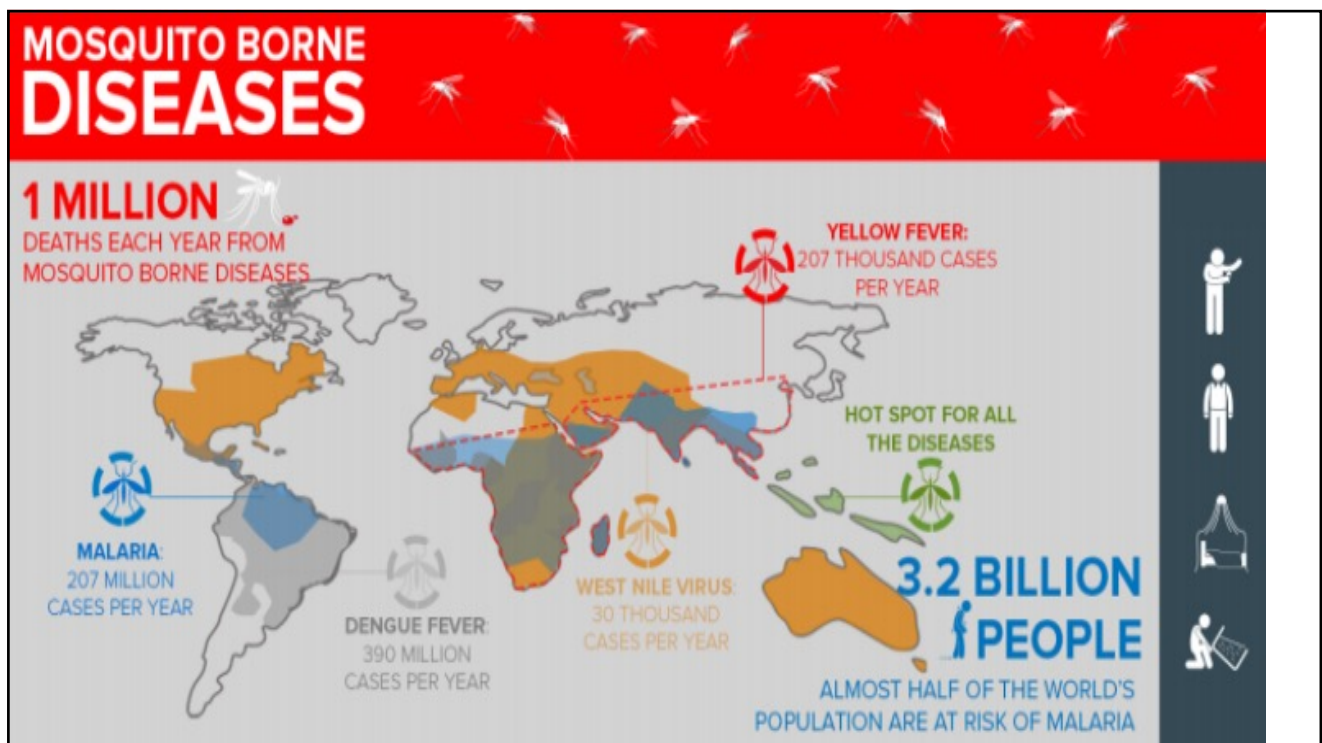
**BILL & MELINDA
GATES foundation**



3

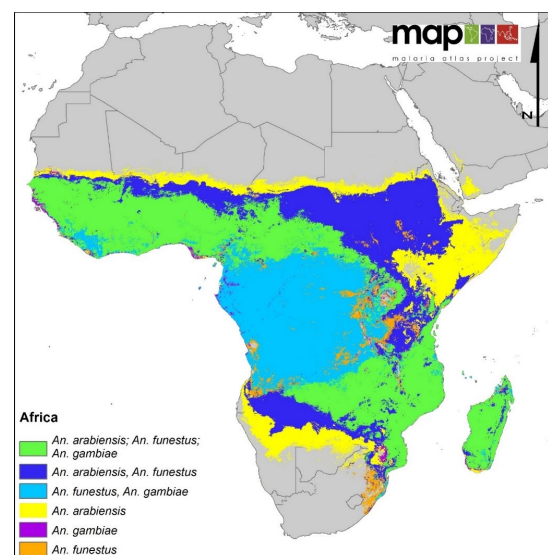
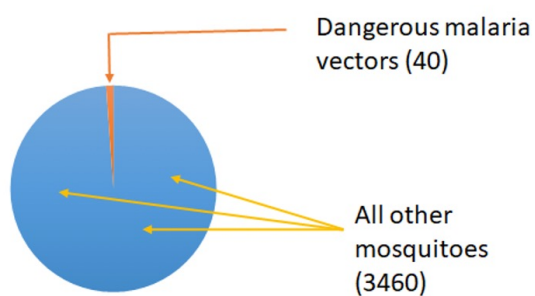


4



5

Mosquito surveillance is essential for effective malaria control



6

Mosquito vector surveillance is:

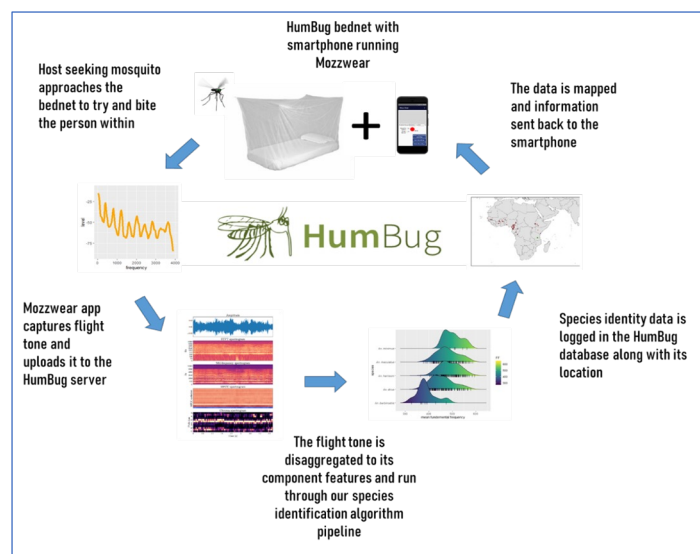
- Time consuming;
- Expensive;
- With current methods, can only be done over limited spatial areas.

‘Gold standard’ methods also can have notable ethical issues...



7

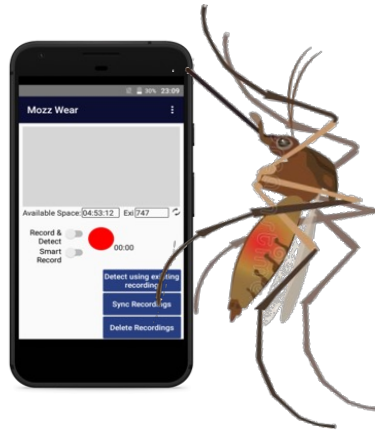
Overall aim: To develop a mobile technology that people can use in remote areas to record the diversity and distribution of mosquitoes



8

?

Can we capture the sound of mosquitoes as they try and bite people in their homes?



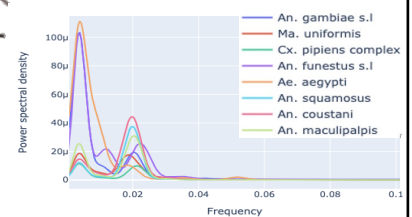
9

?

Can we identify the mosquitoes just using their flight tone as they try and bite people in their homes?



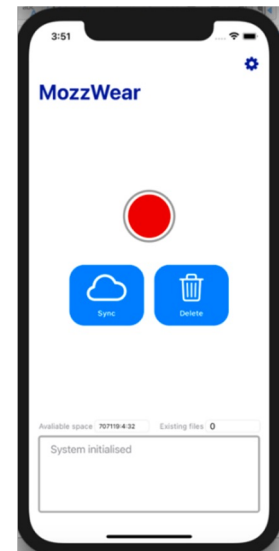
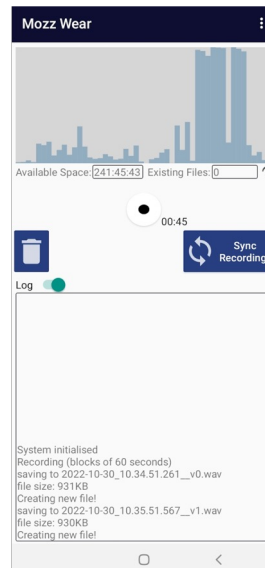
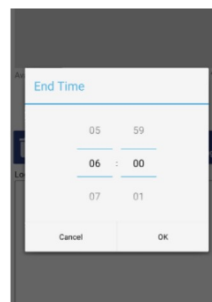
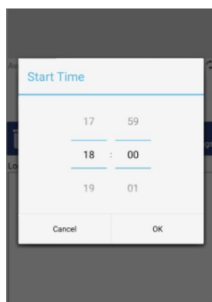
Anopheles arabiensis



10

MozzWear - our frontline data capture app

- Android & iOS apps with a cross-platform app in development
- Scheduled recording
- Live event detection & smart recording



11



12

A mobile technology that people can use in remote areas



13

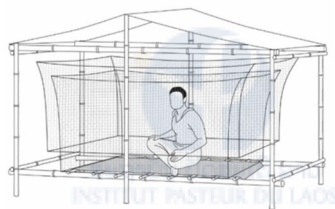


14

Tanzania full field trials (2021-)



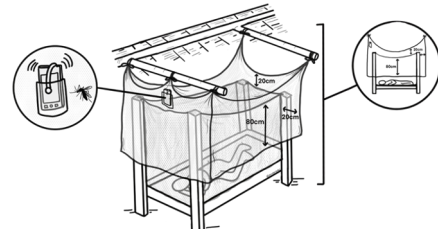
- 12 houses per treatment, all treatments run once a week for three months, **trial began March 2021**



Human Baited Net



CDC-LT

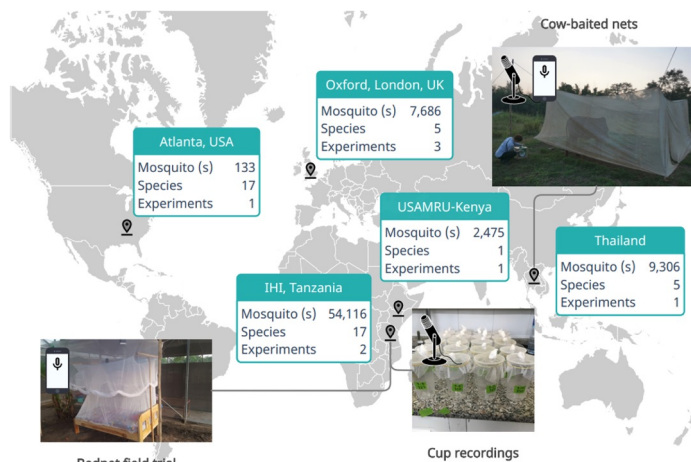
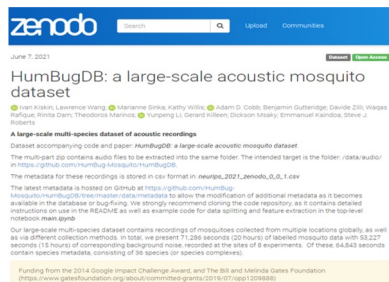


HumBug Net

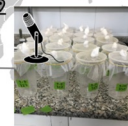
15

The database: HumBug DB

- 20 hours of mosquito sounds from 36 species recorded over 8 experiments globally
- 15 hours of corresponding background
- Complete metadata, such as capture method, feed status, recording device
- Well-maintained and publicly released



Bednet field trial

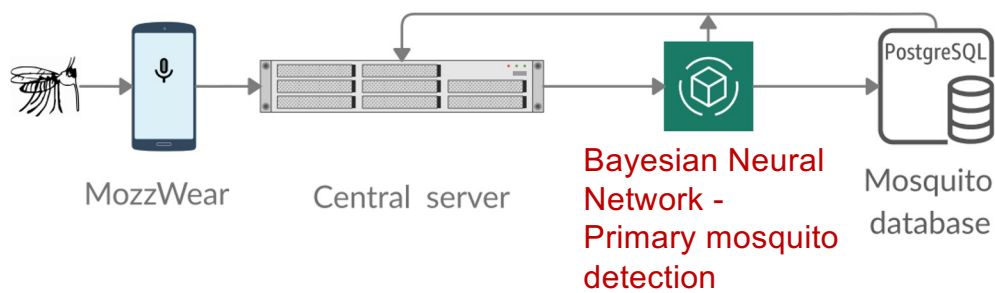


Cup recordings



16

The detection pipeline



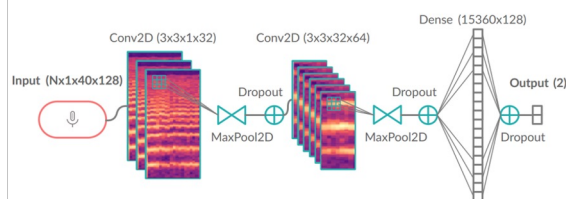
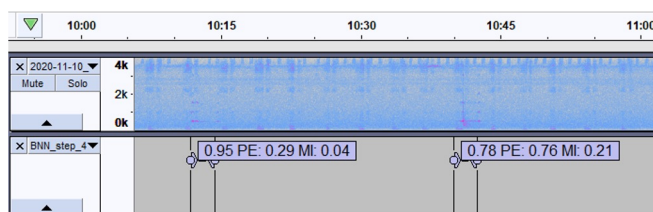
1. **MozzWear** records audio
2. Audio sent to central **server**
3. Bayesian Neural Network (**BNN**) estimates mosquito detection probability
4. Positive predictions screened and stored in **database**
5. Predictions can be visualized on server and used to update model



17

The detection model: Bayesian convolutional neural network

1. Predict with **uncertainty quantified**: human-readable, robust & flexible outputs
2. Model was used to tag data from over 2,000 hours of Tanzanian bednet recordings (now in database)



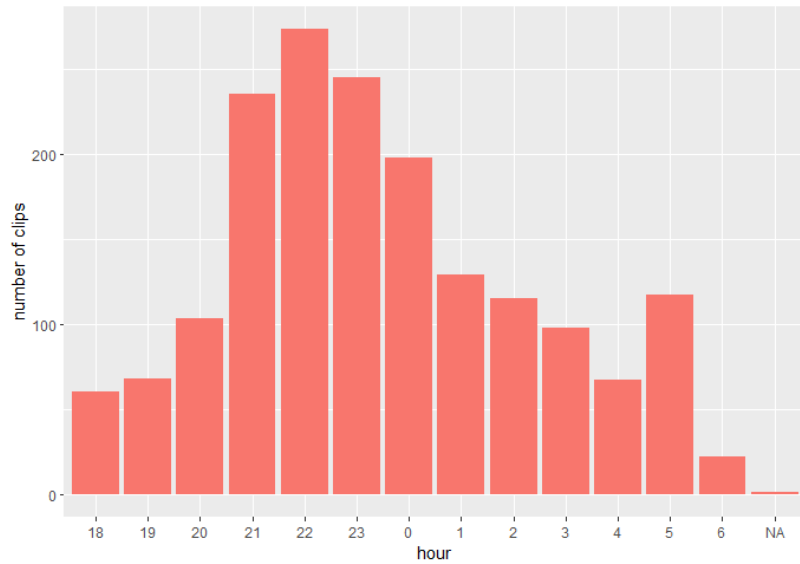
Test A: Tanzanian bednet data

True label	Noise	Mozz
	90.86±0.22	9.14±0.22
Noise	27.36±0.41	72.64±0.41
Mozz		
Predicted label		



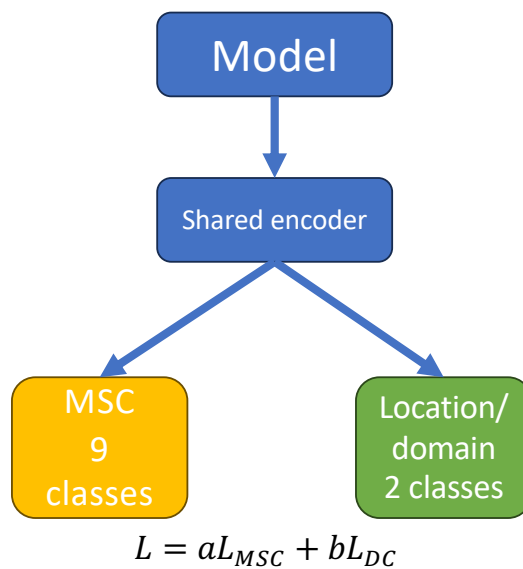
18

- True/positive clips of mosquito flight tone over the sampling night
- Note the peak activity period

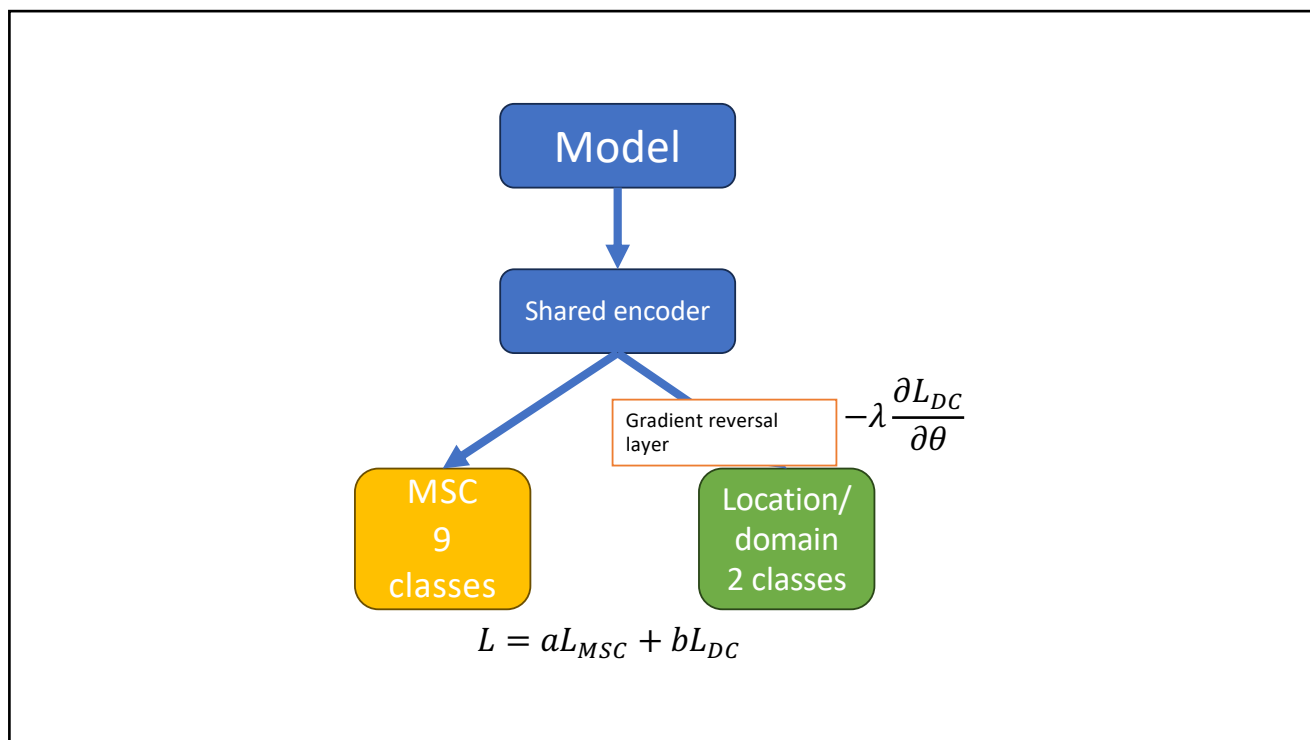


19

Species identification, not phone identification!



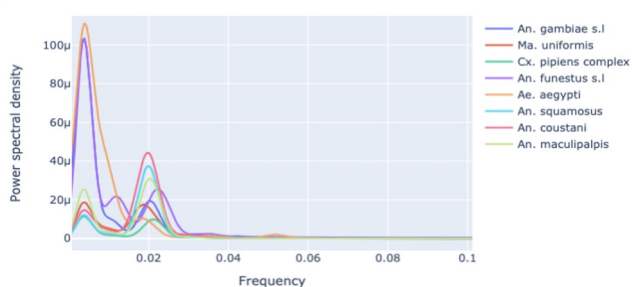
20



21

Multi-species Classification

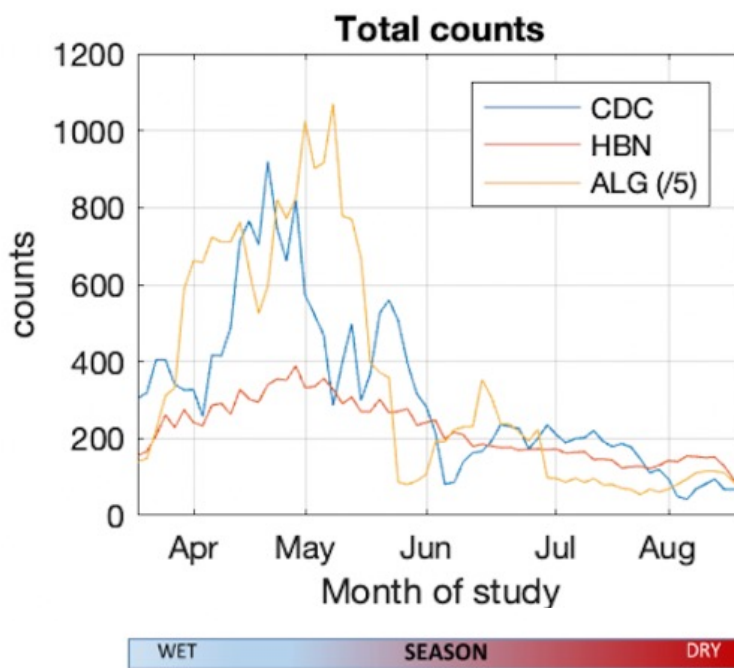
- Pipeline uses mosquito detector to find 'mosquito only' events
- Convolutional (Bayesian) neural network (CNN) for multi-species classification



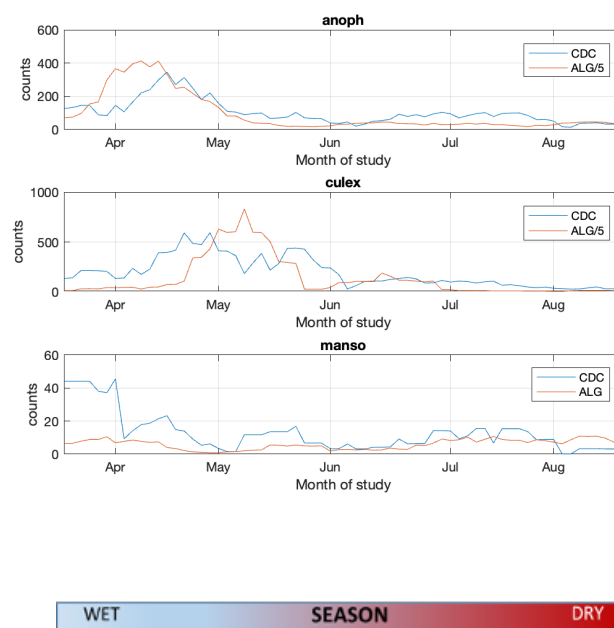
	precision	recall	f1-score	support
0	0.76	0.66	0.71	2911
1	0.67	0.63	0.65	1657
2	0.79	0.70	0.74	1766
3	0.52	0.74	0.61	655
4	0.66	0.89	0.76	411
5	0.57	0.91	0.70	224
6	0.77	0.89	0.83	120
7	0.56	0.87	0.68	173
accuracy			0.70	7917
macro avg	0.66	0.79	0.71	7917
weighted avg	0.71	0.70	0.70	7917

BNN testing chunks								
True label	An. gambiae s.l.	Cx. pipiens complex	An. funestus s.l.	An. squamosus	Ma. uniformis	An. maculipalpis	An. coustani	Ae. aegypti
An. gambiae s.l.	1505	338	166	280	58	92	19	53
Cx. pipiens complex	268	1068	134	76	30	45	13	23
An. funestus s.l.	217	114	1230	83	96	5	3	18
An. squamosus	95	24	17	484	5	6	0	24
Ma. uniformis	18	19	12	10	350	1	0	1
An. maculipalpis	8	13	0	1	0	201	0	1
An. coustani	2	1	0	1	0	4	112	0
Ae. aegypti	8	6	3	9	0	1	0	146
Predicted label	An. gambiae s.l.	Cx. pipiens complex	An. funestus s.l.	An. squamosus	Ma. uniformis	An. maculipalpis	An. coustani	Ae. aegypti

22



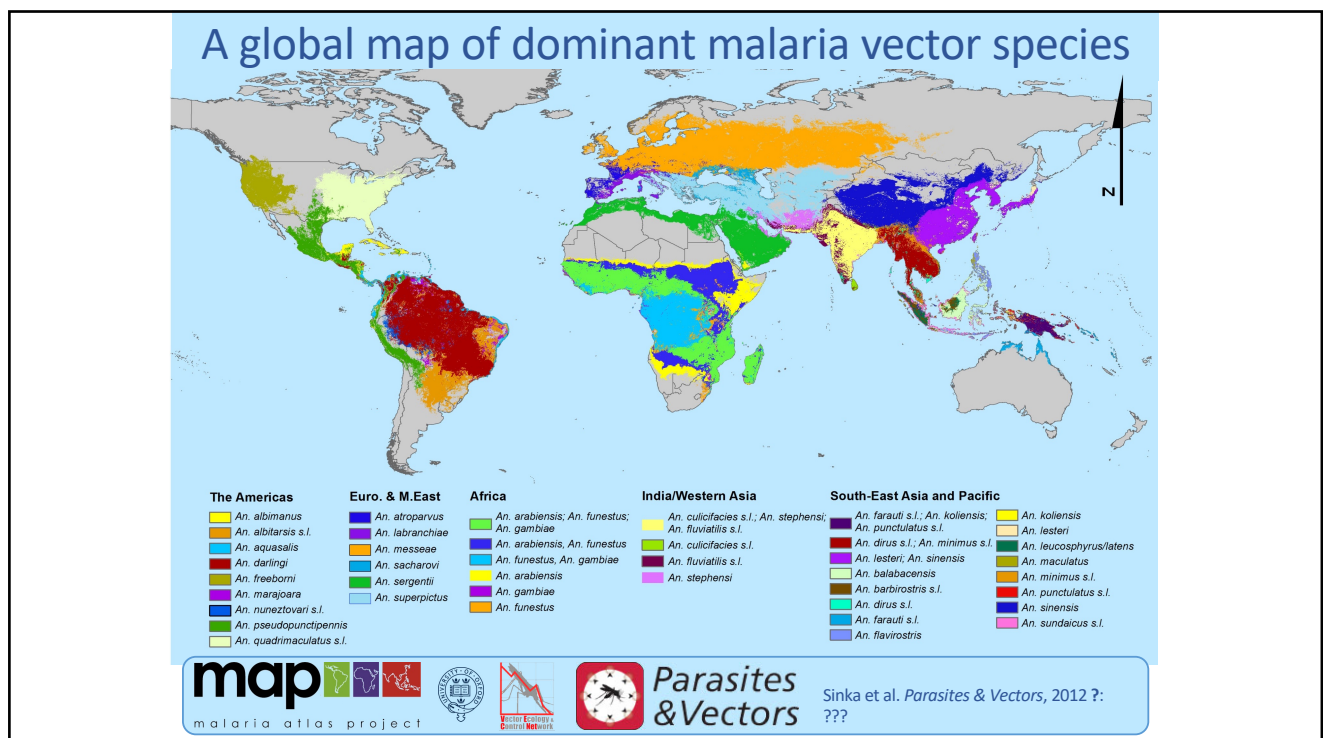
23



24

ALIEN INVASION

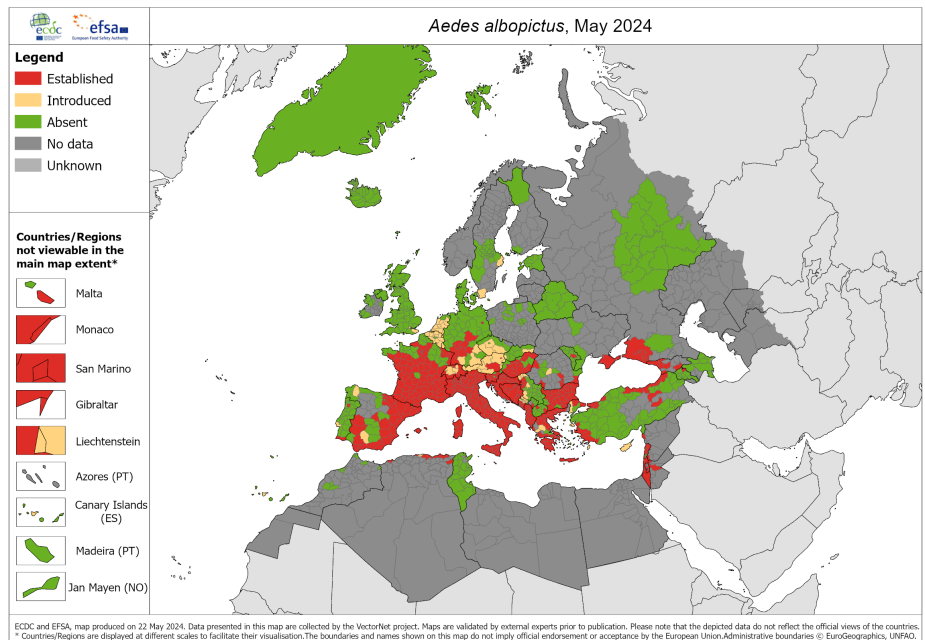
25



26

Since the 1980s – *Aedes albopictus* has spread

- *Aedes albopictus* arrived in the USA in 1987
- In ten years it had spread to 678 counties in 25 states
- It is now fully established across Italy, across south and mid France and moving into the north, eastern Spain and now crossing into northern Africa
- First local transmission of Chikungunya in the south of France in September 2010



27

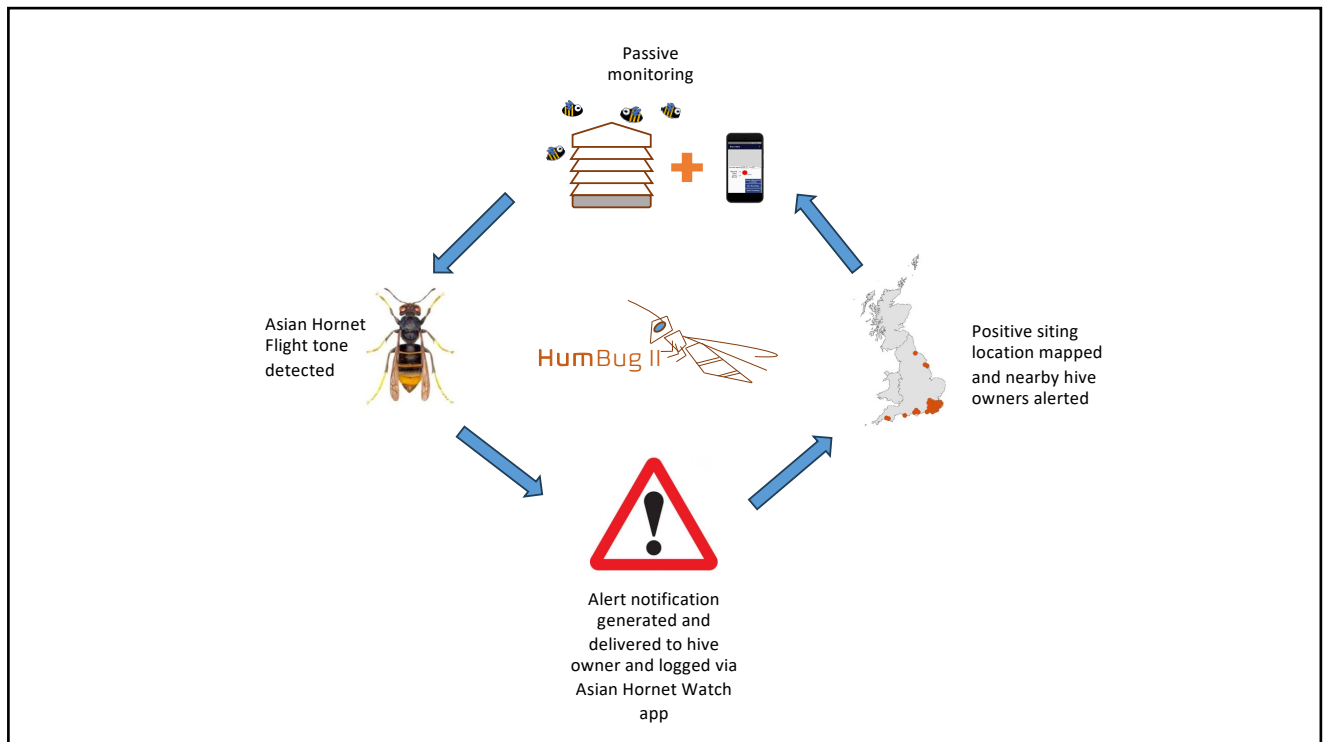
Coming to a hive near you!

HORROR

(Yellow-legged) Asian hornet (*Vespa velutina*)



28



29



30

