INVESTIGATING EBOLA VIRUS DISEASE IN BATS IN GHANA

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Presentation Outline

- Introduction
- Investigation in Ghana
- Results
- Further investigations in Ghana
- Preliminary Conclusion / Discussion
- Next Steps

Filoviruses – Ebola virus

- Fiolviruses – Filoviruses are non-segmented, negative-strand RNA viruses
- family *filoviridae*
- Three genera – Cuevavirus, Marburgvirus, and Ebolavirus
- Causes viral hemorrhagic fevers characterised by coagulating abnormalities
- Potential reservoirs - bats, rodents, arthropods, and plants

Marburg Hemorrhagic Fever

- Causative agent – Marburgvirus originating from Uganda and Eastern Congo.
- Natural reservoir – Unknown, Fruit bats suspected (Egyptian roussette, *R aegyptiacus*) (www.ird.fr)
- Transmission – Initial infection is from exposure in mines or caves inhabited by Rousettus fruit bats. Subsequent human-human through body fluids including blood, excrement, saliva, and vomit with up to 90% fatality.

Ebola Virus Disease

- Ebola is a disease cause by the ebola virus
- Ebola virus disease (EVD) first appeared in 1976 in Nzara, Sudan, and in Yambuku, Democratic Republic of Congo (Near ebola river)
- Five subtypes identified: Zaire, Bundibugyo, Sudan, Reston and Taï Forest
- Four subtypes occur in Africa and cause disease in humans: Ebola-Zaire, Ebola-Sudan, Ebola- Taï Forest and Ebola-Bundibugyo;
- Ebola-Reston, has caused disease in non-human primates and pigs (Phillipines)

Ebola Virus Disease

- Natural Reservoir – Fruit bats, Pteropodidae

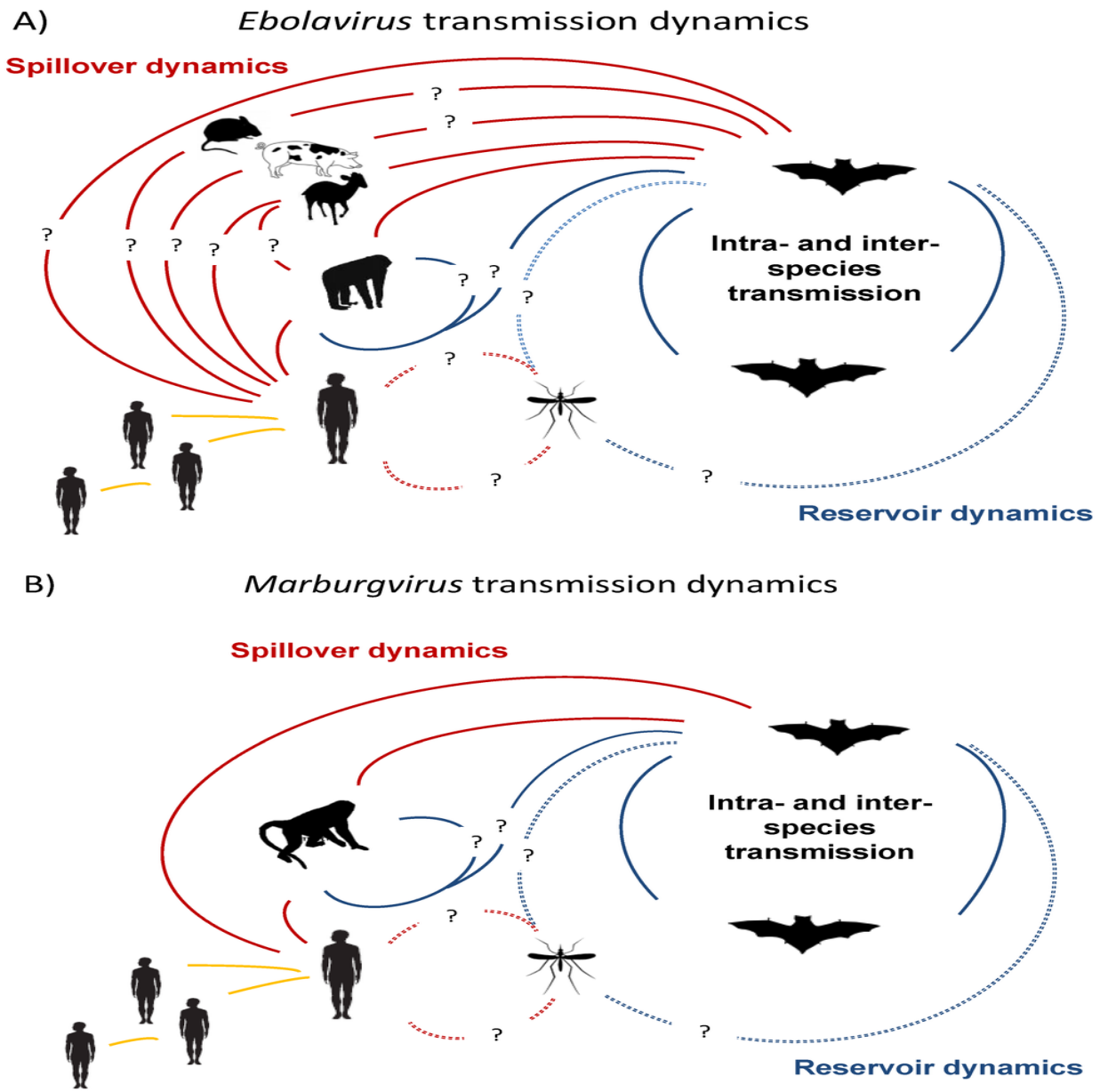
(*Hypsignathus monstrousus, Epomops franqueti, Epomophorus gambianus*)

- Transmission- Direct contact with body fluid of infected animals or carcasses (chimpanzees, gorillas, fruit bats, monkeys, forest antelope and porcupines)
- Incubation: Human – 2 – 21 days; Animals - 3 – 16days
- Symptoms: – fever, vomiting, diarrhea, generalised pain, bleeding (Internal and external) with 25-90% (Ave 50%) mortality of infected people.
- Infected animals are normally found dead or on rare occasion, sick

Transmission pathways of filoviruses

- Broken lines – Uncertain (Vectors)
- Uncertain (Epidemiological pathways
- Blue – Potential reservoirs' dynamics
- Red – Spill-over epidemics
  - Human – Human transmission
  - ? – Pathways with epidemiological uncertainty

Olival, Hayman et al 2014



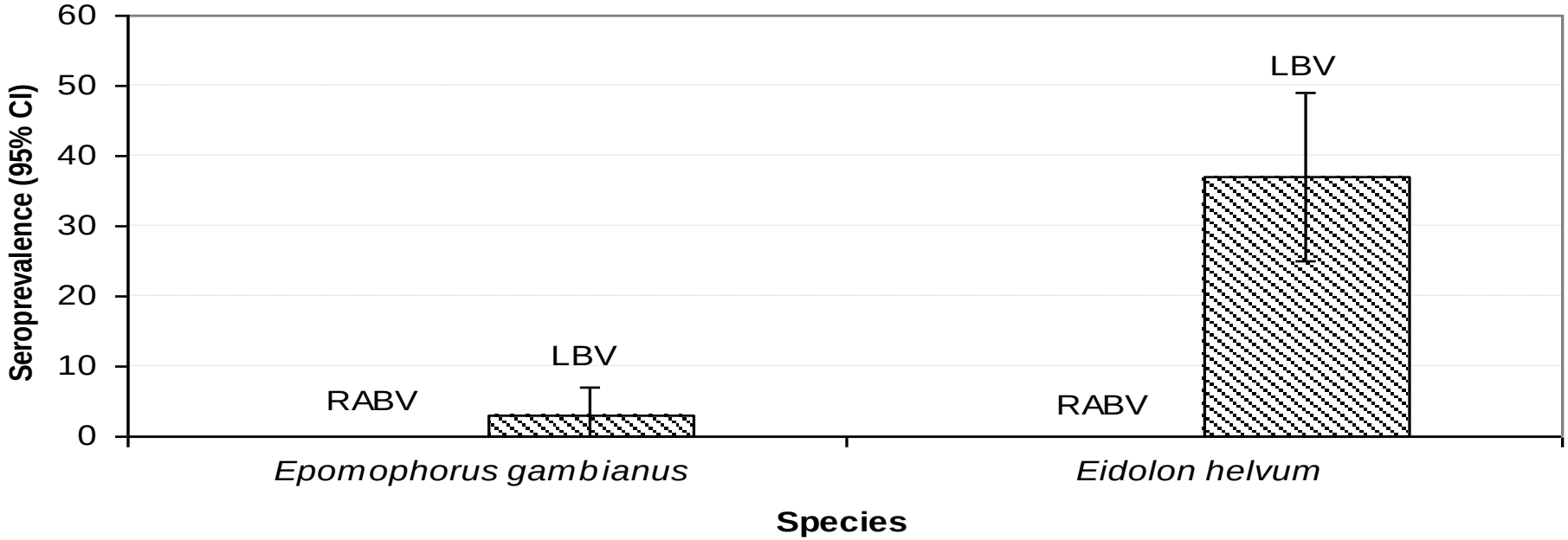
Pilot Study

- In 2007 we conducted a pilot study of zoonotic diseases in fruit bats in Ghana.
- We detected antibodies against
  - Henipaviruses
  - Lagos Bat Virus
  - Ebola virus
  - Marburg virus

Hayman et al., 2008;
Hayman et al., 2010;

Pilot Study

Lyssavirus seroprevalence in commonly caught bat species in Ghana



Hayman et al 2008 *Emerging Infectious Diseases* **14**, 926-8

Serological evidence of Nipah virus

Species	Habitat where caught	Number tested	Number positive (seroprevalence (%), 95% CI)		Percentage adult
			Hendra	Nipah	
Epomophorus gambianus	Open woodland*	89	0	1 (1, 0-3)	62
Eidolon helvum	City colony**	59	13 (22, 11-33)	23 (39, 27-51)	95
Epomops franqueti	Forest**	29	0	0	77
Epomops buettikoferi	Forest**	7	0	0	85
Hypsignathus monstrosus	Forest**	18	0	1 (6, 0-16)	56
Nanonycteris veldkampii	Forest**	4	0	0	100

Hayman *et al.* (2008) *PLoS ONE* 3, e2739 doi:10.1371/journal.pone.0002739

Filovirus Investigation

- We detected a single migratory fruit bat, *Eidolon helvum,* as seropositive against Zaire ebolavirus (ZEBOV) from a large roost in Accra, Ghana
- To understand whether the single seropositive *E. helvum* was evidence of EBOV circulation in the region, or due to chance infection elsewhere in sub-Saharan Africa, we tested the sera of 88 non-migratory fruit bats sampled from the surrounding region in Ghana.

Method

- Bat Site Search:
  - Countrywide Transect drive / Walks (S-N; 2009)
  - Search / Interview of bushmeat traders
  - Community Interview (opinion leaders, hunters etc)
- Bats were trapped (Mist – netting) and sampled (May-June, 2007) - woodland and tropical forest habitats, within 180km from Accra
  - Mostly near / Within fruit Plantation farms

Field bat Search
(Tano Sacred Grove)

Method

- Bats were trapped (Mist –netting) and sampled (May-June, 2007)
- Blood, Faecal and Throat swabs collected
- Demographic data on bats collected (Species, Weight, forearm length, sex, age)
- Blood sera processed for sera at the Accra Veterinary laboratory and stored at -80oC

Method

- Sera Shipped to UK for laboratory investigation
- Antibodies to EBOV was first screened by ELISA
- ELISA-positive samples were tested separately for reactivity against ZEBOV and REBOV NPs by using ELISA and Western blot (WB)

Result

Ebola antibody Prevalence

- We detected antibodies against EBOV in 32/88 bat sera.
- Antibodies to EBOV were detected in:
- 10/27 *Epomops franqueti,*
- *14/37 Epomophorus gambianus,*
- *7/16 Hypsignathus monstrosus,*
- *1/4 Nanonycteris veldkampii and in*
- *0/1 Epomops buettikoferi*

Result

Ebola antibody Prevalence

- 13 of the 32 EBOV-positive serum samples were positive for EBOV (When tested against an individual NP)
- 9 /13 were ZEBOV-positive only (*E. Franqueti (3)*, *E. Gambianus (4)* and *H. monstrosus (2)* bats)
- 3 were REBOV-positive only (from 2 *E. gambianus (2)* and *H. monstrosus (1)* bats), and
- 1 sample from an *E. gambianus* bat was positive for both ZEBOV and REBOV.

Further investigations in Ghana

- 2012 we investigated bats (Egyptian fruit bats (*Rousettus aegyptiacus*)) at Bouyem caves in the Techiman district, B.A

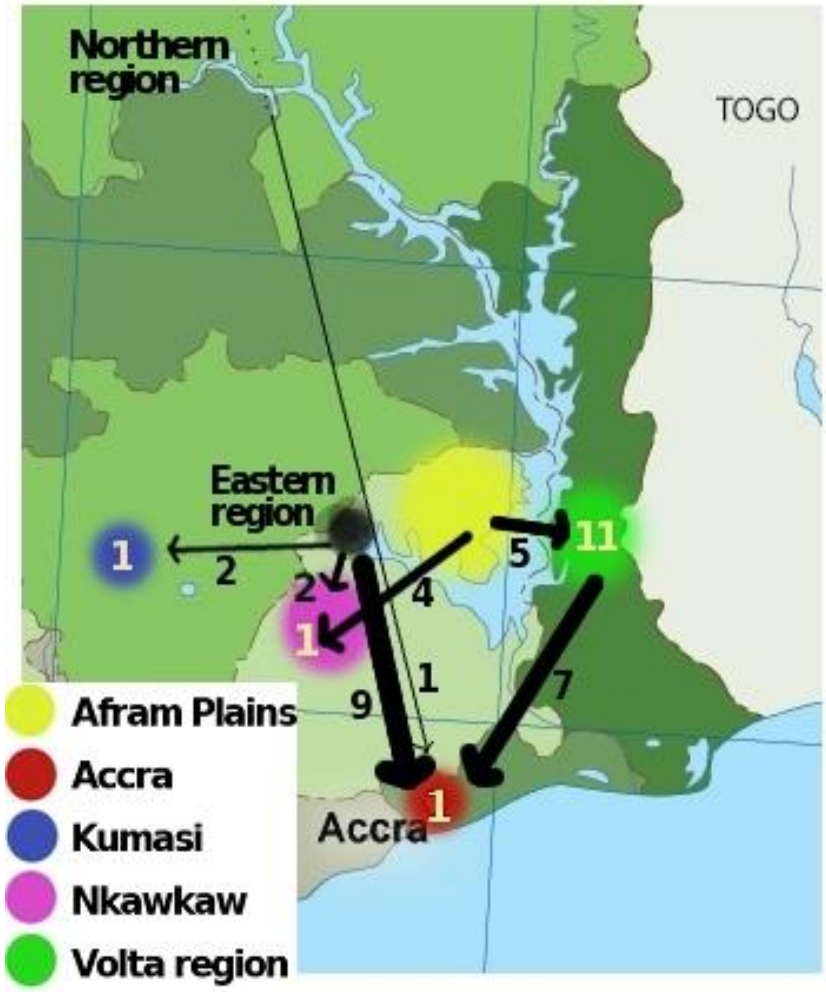
Further investigations in Ghana

- We trapped and sampled 21 Egyptian fruits bats (*E. egyptiacus*).
- We detected antibodies to Filoviruses (Ebola - 5% and Marburg (9%) viruses) in Bouyem caves using validated Luminex binding assays

Further Investigations in Ghana

2. Study carried on Bushmeat commodity chain:

- 100,000-200,000 bats harvested/year
- Between 30-80% of Ghanaian interviewees consume bat meat
- Risk group: People handling fresh meat and carcasses - hunters , butchers and consumers
- Commodity chain means disease in one bat population could affect people far away



Preliminary Conclusion / Discussion

- We detected a relatively high proportion of seropositive animals in a relatively small, mixed-species, sample size, suggesting that the prevalence of EBOV in these bat species is greater than previously detected in *E. helvum* (1/262 sera) .
- The bat species involved are non-migratory. Our findings suggest that at least one serotype of EBOV circulates in bats in the Upper Guinea forest system in West Africa.
- Cote d'Ivoire EBOV (CIEBOV) is the only reported EBOV in this part of Africa(Le Guenno et al., 1995)
- The finding is most westerly evidence of EBOV circulation found in African bats to date, and the first to show circulation within this ecosystem

Preliminary Conclusion / Discussion

- These findings are interesting because they include:
- 2 species (*E. franqueti and H. monstrosus)* previously found serologically and viral antigen positive against EBOV in Gabon in Central Africa (Leroy et al 2005), and
- 2 species *(E. gambianus and N. veldkampii)* not previously identified as potential reservoirs.

Stakeholder meeting on bat viral findings in Ghana

Preliminary Conclusion / Discussion

- The Questions are:
  - How is the virus maintained in bats
  - Is there spill-over to other domestic wildlife and human
  - How, where and when does spill-over / transmission occur

On-going Investigations

- Ecology of bats in Ghana (University of Ghana, DDAC Project):
  - Bat colony search through nationwide transect drive / Walk (2013 – 2015)
  - Use of School Conservation NGOs and Wildlife clubs
  - Mapping the distribution of bats in Ghana and West Africa

On-going Investigations

- Bat colony search using citizen science approach (Newspaper advert)
  - Bat trapping at colonies and identification of species
  - Monitoring bat populations
  - Bat behaviour study – Tracking the movement of bats (GPS Loggers)

Curtesy: M. Abedi-Lartey

Recommendation

- Our results, therefore, ask the question as to what factors (e.g. host, ecological) limit EBOV circulation in *E. helvum*.
- Virus isolation is required to characterize the ebolavirus(es) circulating in fruit bats in Ghana
- In addition, possible public health threats should be investigated and addressed.
- These initial findings, however, suggest that human infection risk might be higher from bat-human contact in rural and forest settings than from urban-roosting *E. helvum.*

Recommendations

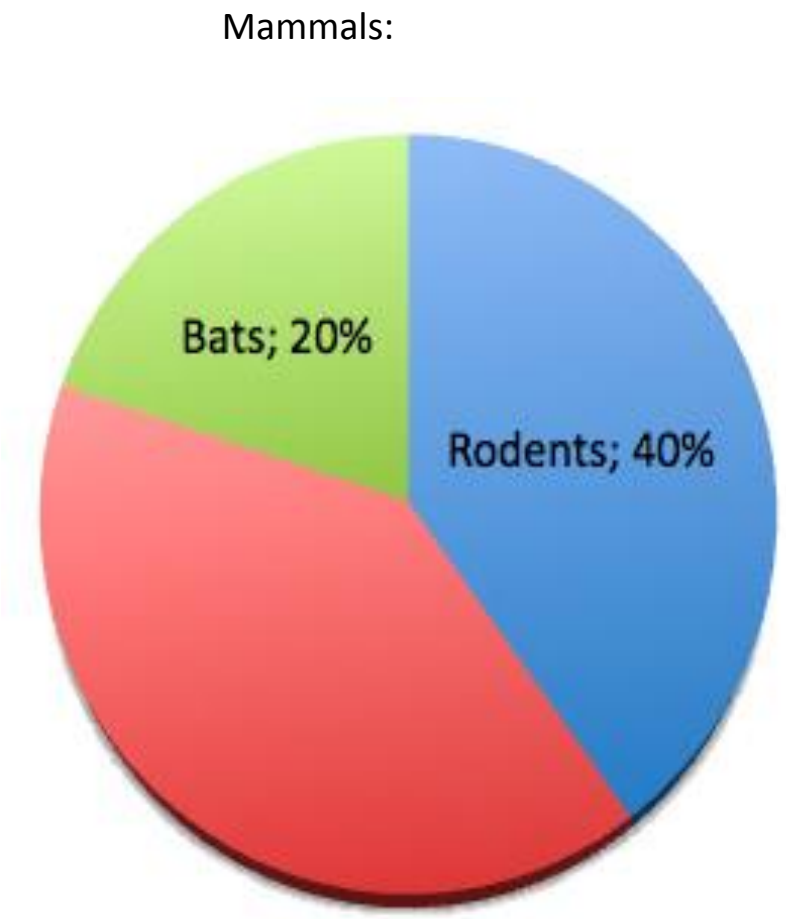
- Need to investigate role of other wildlife (Bush Meat) in the epidemiology of EVD in West Africa

Next Steps

- Further testing, including longitudinal sampling of bats, is conducted to further investigate the epidemiology of EBOV in West Africa.
- Study to isolate and characterise Ebolaviruses in Bats and domestic animals (pigs)
- We are conducting social study to investigate health seeking behaviour of communities in Buoyem

Bats, Probable Reservoirs

- Most abundant, diverse, and geographically dispersed mammals
- 1,232 species - 20% of mammalian species are bats
- Metapopulation structure - Dense colonies, >100000, sometimes millions. They can hence maintain infections within a population.



Bats and Infections

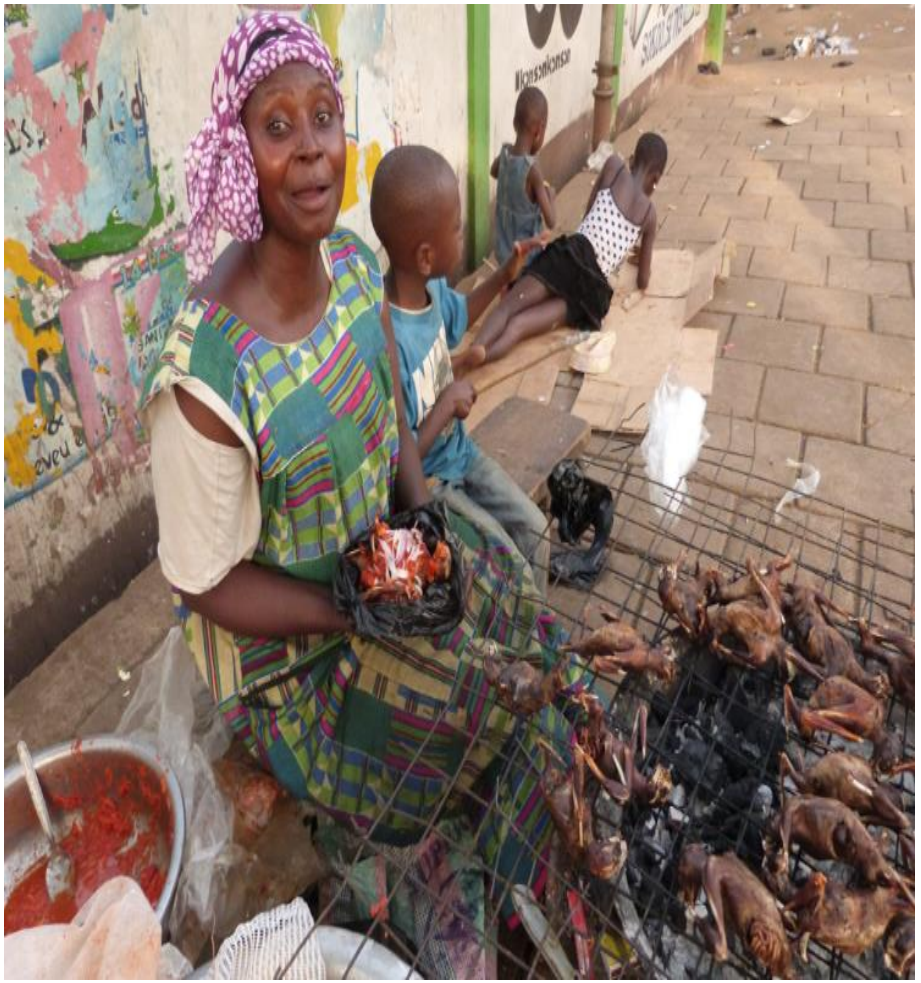
- Evolved ~65 mya, with great diversification early in mammalian history (Eocene period, 52 to 50 million years ago)
- Little evolutionary change compared to other mammal taxa
- Long history of association or co-speciation with their viruses
- Metapopulation structure –

Dense colonies, >100000 and in millior

They can hence maintain infections within a population

Ecosystem importance

- Bushmeat. An estimated minimum of 128,000 sold / year in a 400 km radius in Ghana. Worth GhC 256,000 to the consumer (Kamins et al., 2011)
- Provide key ecosystem services - Pollination, Seed and pollen dispersal and help in forest re-generation, Control of insect-borne diseases



Public Health Importance of Bats

- Bats are associated with zoonoses of potentially great global public health impact –lyssaviruses, paramyxoviruses (Henipah viruses(HeV), SARS coronavirus), filoviruses (Ebola and Marburg viruses),

THANK YOU

3rd International Conference on Rabies in West Africa (RIWA)

"Harmonizing Stakeholders and Tools for the Prevention and Control Of Rabies"

March 23 – 26, 2016

www.riwaconference2016.com

References

- Thomas H. Kunz,1 Elizabeth Braun de Torrez, Dana Bauer, Tatyana Lobova, and Theodore H. Fleming. Ecosystem services provided by bats. Ann. N.Y. Acad. Sci. ISSN 0077-8923
- Hayman DTS, Emmerich P, Yu M, Wang LF, Suu-Ire R, Fooks AR, et al. Long-term survival of an urban fruit bat seropositive for ebola and lagos bat viruses. PLoS One. 2010;5(8)
- Hayman DTS, Yu M, Crameri G, Wang L-F, **Suu-Ire R**, Wood JLN, et al. Ebola virus antibodies in fruit bats, Ghana, West Africa [letter]. Emerg Infect Dis [serial on the Internet]. 2012 Jul [*date cited*]. DOI: 10.3201/eid1807.111654
- A.O. Kamins, O. Restif , Y. Ntiamoa-Baidu **, R. Suu-Ire** , D.T.S. Hayman, A.A. Cunningham ,J.L.N. Wood, J.M. Rowcliff . Uncovering the fruit bat bushmeat commodity chain and the true extent of fruit bat hunting in Ghana,West Africa. Biol. Conserv. (2011), doi:10.1016/j.biocon.2011.09.003
- Ntiamoa-Baidu, Y., 1998. Wildlife Development Plan 1998–2003. Sustainable Use of Bushmeat: Wildlife Department, Ministry of Lands and Forestry, Republic of Ghana, Accra 6
- Leroy EM, Kumulungui B, Pourrut X, Rouquet P, Hassanin A, Yaba P, et al. Fruit bats as reservoirs of Ebola virus. Nature. 2005 Dec 1;438(7068):575-6.
- http://www.who.int/mediacentre/factsheets/fs103/en/
- http://www.cdc.gov/vhf/ebola/outbreaks/history/distribution-map.html

Reference

- Le Guenno B, Formenty P, Wyers M, Gounon P, Walker F, Boesch C. Isolation and partial characterisation of a new strain of Ebola virus. Lancet. 1995;345:1271–4. http://dx.doi.org/10.1016/S0140-6736 (95)90925-7
- Germain, M. Collection of mammals and arthropods during the epidemic of haemorrhagic fever in Zaire. In *Ebola Virus Haemorrhagic Fever; Pattyn, S.R., Ed.; Elsevier: New York, NY, USA,* 1978; pp. 185–189.
- Arata, A.A.; Johnson, B. Approaches toward studies on potential reservoirs of viral hemorrhagic fever in southern Sudan (1977). In *Ebola Virus Haemorrhagic Fever; Pattyn, S.R., Ed.; Elsevier:* New York, NY, USA, 1978; pp. 191–200.
- Leirs, H.; Mills, J.N.; Krebs, J.W.; Childs, J.E.; Akaibe, D.; Woollen, N.; Ludwig, G.; Peters, C.J.; Ksiazek, T.G. Search for the Ebola virus reservoir in Kikwit, Democratic Republic of the Congo: Reflections on a vertebrate collection. *J. Infect. Dis.* ***1999, 179(Suppl. 1),*** S155–S163.
- Swanepoel, R.; Leman, P.A.; Burt, F.J.; Zachariades, N.A.; Braack, L.E.; Ksiazek, T.G.; Rollin, P.E.; Zaki, S.R.; Peters, C.J. Experimental inoculation of plants and animals with Ebola virus. *Emerg. Infect. Dis.* ***1996, 2, 321–325.*** **www.ird.fr**
- Kümpell N, Cunningham AA, Fa JE, Jones JPG, Rowcliffe JM, Milner-Gulland EJ. (2015) Ebola and bushmeat: myth and reality. Food and Agriculture Organization of the United Nations NWFP Update 2015/1. http://forestry.fao.msgfocus.com/files/amf_fao/project_95/Feb_2015/Bushmeat_Ebola_Myth_an d_RealityN.pdf

Bush Meat Commodity Chain

- Bush meat is an important economic and nutritional commodity in West Africa
- Estimated annual bush meat harvest in Ghana (1998) – 384,991.8 metric tons (worth US$350million) contributing 75% of the daily protein intake in Ghana.
- It is a main source of protein for both the rural and urban poor.
- Bush meat commodity chain involve; Rural and urban communities, farmers, market sellers, hunters.
- Impact is thus due to lost of livelihood of rural and urban poor.

Discussion 3/4

- Although Ebola in people has previously been associated with direct transmission from fruit bats (Leroy et al. 2009), the risks from bat viruses are not new and immediate, but are long-established and of low probability.
- This needs to be reflected in the communication of the public health message.
- The current demonization of bush meat risks being counter productive, as trust in authority will be lost when hunters and consumers identify the mismatch between public awareness messages and reality (Kümpell et al. 2015).

Ecosystem Importance

- Regulatory services of bats - arthropod suppression, pollination, and seed dispersal:
  - 289 Species of plants depend on large populations of old - world fruit bats for propagation (Fujita & Tuttle 2005)
  - Many are economically important food or timber producing plants (Fujita & Tuttle 2005)
  - Fruit bats have long gut retention of seeds : improved dispersal potential (Shilton et al. 1999)
  - Responsible for 96% of forest regeneration / rejuvenation (Thomas 1988)
  - Insectivorous bats feed on insects and control many insect borne diseases including malaria.