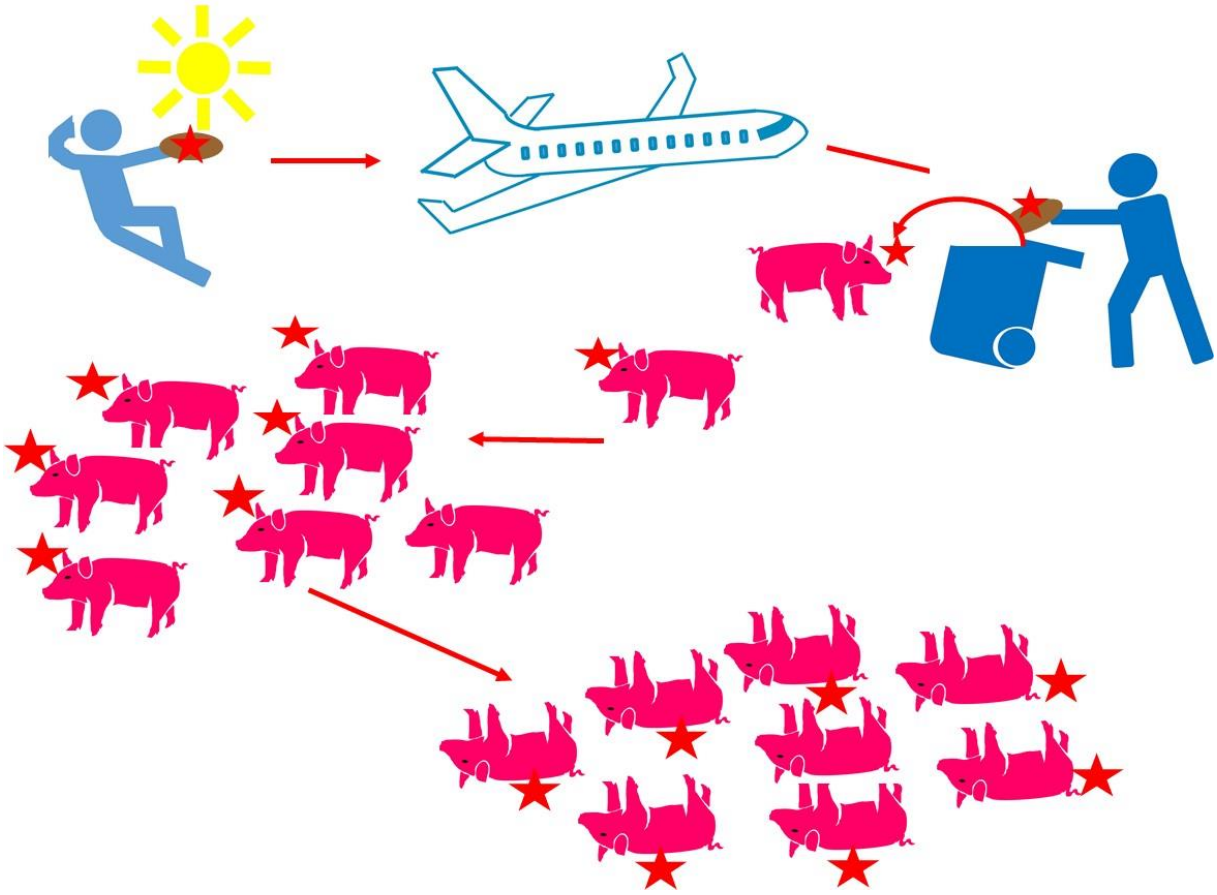
The food animal plagues

Mum, why are we not allowed to take home this wonderful ham from our vacation?



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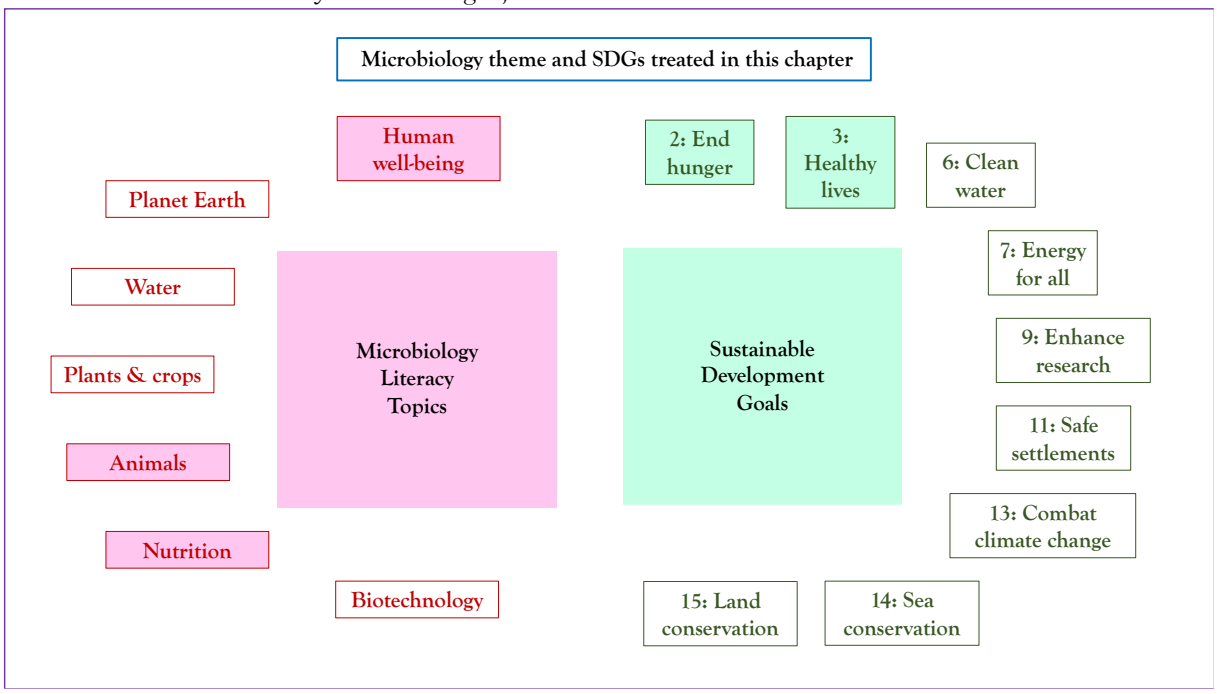
Storyline

How do animal plagues spread? What is the harm to animals, society and the environment? Everyone has the responsibility to take simple and efficient measures to prevent animal plagues.

The Microbiology and Societal Context

The microbiology: epidemics; pathogen transmission; zoonoses; vaccines; infection eradication; One Health. *Sustainability issues:* hunger; health.



The food animal plagues: the Microbiology

1. ***Feeding the world.*** World food production has shifted from the supply of cereals to protein-rich diets based on livestock and fishery products. For the last 10 years, cattle, pig and chicken products lead the global ranking of food and agriculture commodities.

Rank	Commodity	Production value (billion US$)
1a	Rice	180
1b	Cow milk	180
3	Cattle meat	172
4	Pig meat	168
5	Chicken meat	122
6	Wheat	81
7	Soybeans	66
8	Tomatoes	55
9	Sugar cane	54
9b	Maize	54

Global ranking of food and agriculture commodities in value (FAO 2013)

Food animals play a central role in supplying the world's human population with valuable proteins from milk, egg and meat. In return, humans are responsible for the welfare of food animals such as cattle pigs and chicken. Food animals make a significant contribution to greenhouse gases, which are responsible to the global climate change. The animal protein sources must therefore be considered as a precious good, to be produced sustainably and consumed temperately. Most important, therefore, is to take care of the food animal's health.

2. ***Animal husbandry: key role of infectious diseases and importance for One Health.*** Due to the relatively high population densities of animals in commercial husbandry operations, which favours the transmission of infectious agents, the highest health risk for food animals is infectious diseases caused by virus, bacteria and parasites. These often cause severe outbreaks, epidemics or even pandemics, putting the life of millions of animals and animal owners in danger.

Since the most severe infectious diseases of humans, such as smallpox, brucellosis, AIDS, SARS and the recent Covid-19 pandemic, originate from the animal kingdom and were mostly transmitted by animal food, humans are well advised to carefully prevent food animal plagues.

The involvement of everyone is needed to achieve this goal. Hence, society must understand how the pathogenic microorganisms transmit to food animals and spread in the herds where they cause devastating epidemics. Animal health plays a central role in sustainable development of the World's population, and is a key element of One Health.

3. ***Food animals in society.*** Food animals are kept very differently in the various parts of the world. In richer countries, livestock owners hold food animals in relatively large herds. Large herds are more easily and more economically managed but, if a dangerous virus or bacterium gets into the herd, many animals are rapidly infected, which leads to an extreme multiplication of the pathogen. Subsequently the pathogen can then be spread rapidly either directly from animal to animal, by contaminated persons, by transport vehicles or goods that are transported to other herds thus creating epidemics.

In poorer countries, food animal herds are generally smaller. They represent often the wealth of a family or community. In these countries, transhumance – the seasonal movement of livestock between summer and winter pastures – is frequent and facilitates the spread of diseases over large distances though at a slower rate. However, the spread of the diseases remains often undetected for a long time before epidemics occur in large areas.

4. ***Management of epidemics.*** The control of the spread or hopefully the successful eradication of food animal plagues need methods that are tailored to the circumstances in the respective countries. For example, some diseases, such as contagious bovine pleuropneumonia — a bacterial respiratory disease with high death rates — can be controlled in Western countries by the quarantining and slaughtering of affected animals. However, such methods are not effective for herds in Africa, where animal movements are not easily controlled and people cannot afford to slaughter their animals as long as they survive the infection, even at the risk of spreading the disease. In these cases, vaccines with high efficacy and good stability that can easily be used to immunize animals are necessary.

5. ***Classical food animal plagues.*** The following examples describe a few classical food animal plagues. They were chosen to demonstrate how they have an unequal impact on the socio-economic development of various societies on different parts of the world. In addition, they also show how the personal behavior of individuals can contribute to reduce the spread of such plagues.

a. *Swine fever: the contribution of the public to avoid the plague*. Swine fever, correctly named African swine fever, is a highly contagious hemorrhagic disease caused by a DNA virus of the *Asfarviridae* family. It affects pigs, warthogs, European wild boar and American wild pigs. It is harmless to humans and most other animals. The disease is characterized by a rapid onset of high fever, loss of appetite, haemorrhages in the skin and internal organs, and death in 2-10 days. Mortality rates often reach 100%. There is currently no treatment or vaccine for African swine fever. In countries with dense pig production, epidemics can produce tremendous losses.

A huge outbreak of African swine fever in mainland China during the period 2018–2020 resulted in more than 100 million pigs dying from the disease, or being culled to prevent spread of the plague. Culling caused heavy environmental pollution and shortage of pork, which is China's most popular meat, driving up consumer prices to record levels due to the necessity to import.

Prevention in countries free of the disease depends on stringent import policies, ensuring that neither infected live pigs nor pork products are introduced into areas free of African swine fewer. This includes a ban on import of live swine and pork meat, as well as proper disposal of waste food from aircraft, ships or vehicles coming from infected countries, in some cases a full decontamination of entire shipments.

This is the reason why the import of pork is forbidden in many countries and why at customs passengers sometimes are obliged to trash their delicious smoked ham they bought on vacation. Many passengers often perceive this obligation as an intrusion of their freedom and private lives. However, a single piece of ham or a ham-sandwich discarded in a plastic bag in a household waste bin that might subsequently be torn open by cats, foxes and birds, can cause a most severe epidemic in an African swine fever free country. The discarded ham might be eaten by a wild boar which may become infected and subsequently transmit the disease to domesticated pigs, triggering an epidemic with huge losses. Here a well-informed public can make a substantial contribution to avoidance of catastrophic epidemics.

In endemic areas, it is difficult to eliminate the natural reservoirs of African swine fever, such as infected warthogs. Eradication of African swine fever is generally very expensive as it necessitates the culling of ten to hundreds of thousands of animals. The damage is not only economic but also ecological due to unnecessary spent feed that caused production of greenhouse gases. Furthermore, disposal of animals, which for safety reasons must be done by burning, causes considerable air pollution.

All successful eradication programs have involved the rapid diagnosis, slaughter and disposal of all animals on infected premises, thorough cleaning and disinfection, movement controls and surveillance programs. In countries where culling of animals is not possible for social reasons, once endemic, the disease might stay for centuries and affect the welfare of households of millions of people.

b. *Foot and mouth disease: Necessity of professionalism from waste treatment to animal husbandry*. Foot and mouth disease – FMD – is caused by an aphthovirus, which infects cloven hoofed animals, including domestic and wild bovine and sheep and also pigs. The virus is one of the most infectious agents known and is able to survive a long time outside of the animal host.

The viral infection causes high fever followed by blisters inside the mouth and feet, and often leads to lameness. FMD has most severe implications in animal farming. The virus can very easily spread by contaminated farming equipment, staff working on the farm or other secondary contaminated persons visiting the farm, vehicles and feed. Even a handshake of a contaminated person with a farmer is sufficient to transmit the disease to his farm.

Since the virus is highly variable, vaccination has generally only a very low impact. Hence, strict hygiene measures are the only efficient means to control the disease. Once the disease has

broken out, all susceptible animals within a given perimeter, have to be slaughtered. This means farms having its entire livestock killed and burned, which causes enormous economic, socioeconomic and environmental damage.

The 2001 outbreak in the UK illustrates this well. The first case to be discovered was at an abattoir in Essex in February 2001. Cases were then discovered in Devon, Northumberland and North Wales in the same week when the first mass slaughter was held in order to try to contain the virus. However, the disease had already spread and, a week later, cases were confirmed in Cornwall and Scotland. The subsequent culling policy required not just the animals on the affected farms to be killed, but also all the animals in the surrounding area. Exclusion zones made travel in some areas almost impossible and had an effect on tourism as travel was forbidden.

Despite these measures the epidemic continued. The epidemic had been eradicated only in September 2001 and cost the slaughtering and burning of 6 million animals that were brought into the world with a lot of work and dedication. It cost the UK public sector £ 3 billion and the private sector £ 5 billion.

The origin of the epidemic was a pig farmer who frequently fed his animals with untreated catering waste from restaurants and local school canteens. Solely the food remains of a single person, who, after returning from vacation in a FMD-endemic area, was eating in a restaurant or canteen and left part of the meal that was then used for feeding animals without prior safety treatment, is thought to be the cause of the disaster.

As long as FMD is not eradicated worldwide, strict hygiene measures must be applied along the whole food and feed supply chain. These facts should be understood by the public in order to help to prevent devastating epidemics.

c. *Rinderpest: A success of a worldwide vaccine campaign.* Rinderpest or cattle plague was a severe infective viral disease that devastated cattle and other domesticated animals and their owners across Eurasia and Africa for hundreds of years. The rinderpest virus – RPV – a morbillivirus of the paramyxoviridae, is closely related to the human measles virus, which most likely evolved from RPV some 3000 years ago. It caused epidemics in cattle, and buffaloes, but also decimated wild ungulates such as antelopes, deer, giraffes, wildebeests and warthogs, which often re-infected domestic herds. The disease was difficult to control in countries with transhumance where the domesticated animals of nomads also had contact with wild ungulates.

Rinderpest was mostly transmitted by direct contact between animals or by drinking contaminated water. The infection caused high fever, diarrhea, lymphoid necrosis and oral erosions with high mortality reaching up to 100% in immunologically naïve herds. This led to famine in many countries. An estimated one third of the population of Ethiopia and the Maasai ethnic people in Tanzania and Kenya died of starvation, mostly due to animal losses by rinderpest.

The rinderpest epizootic also perturbed the ecological balance in parts of the African continent by reducing the number of grazing animals, which prevented grassland from converting into coverts that represent ideal breeding ground for the tsetse fly and consequently spread of many fly-transmitted diseases such as malaria. However, in the last century, rinderpest also devastated cattle breeding in many Asian countries.

In 1993 the Food and Agriculture Organization of the United Nations, FAO, initiated the Global Rinderpest Eradication Programme (GREP). It relied on mass vaccinations with a new efficient vaccine that did not need freezer cool chains, and so could be used in remote areas, and epidemiological surveillance by simple efficient and reliable diagnostics. In 2001, the last confirmed case was diagnosed which allowed to reduce the vaccination campaign to a few critical areas. In May 2011 the World Organization for Animal Health (OIE) and in June 2011 the United Nations FAO confirmed the disease was eradicated, making rinderpest only the second disease in history to be fully wiped out, after smallpox (OIE, 2011).

In June 2019, the Pirbright Institute in Surrey, UK, which stored most of the rinderpest virus samples, destroyed all stock, following a compilation of digital records of the full genome sequences of the virus samples, and replacing active viral samples. The United Nations requested all other laboratories to destroy their samples, in order to fully eradicate the virus from Earth.

Eradicating Rinderpest globally may also have an impact on human health: if measles can also be eradicated, re-appearance of measles through mutation of the Rinderpest virus will no longer be possible.

6. ***Human and animal medicines are interlocked: Avian influenza – a need for a One Health approach.*** In May 1997, a child infected with an influenza virus in Hong Kong died with Reye's syndrome, in spite of the absence of a flu epidemic. The influenza virus isolated failed to be typed with conventional seasonal human influenza antisera by the responsible laboratories. At the same time, the veterinary authorities struggled with a severe outbreak of a particular Influenza A serotype H5N1 that is highly pathogenic for domesticated birds, chicken, ducks and turkey. The outbreak reached unprecedented global spread, when hundreds of millions of chickens, ducks and turkeys, in particular in Asia, died or were culled.

The infection patterns could be traced back to transportation routes – roads and railroads. Since H5N1 at this time was not considered to have public health relevance, the public health authorities were not aware of this event. However, months later it was found that the dead child been infected by H5H1, probably due to a very high virus load acquired at a live poultry market (Claas et al 1998).

In order to avoid further transmissions to humans, live bird markets disappeared in the city centers of Hong Kong for safety reasons. The severe epidemic in Hong Kong in 1997 led to the development of the One Health concept that is since applied to other emergent diseases, such as zoonoses caused by the SARS corona virus and influenza H1N1, a different subtype, known as swine flu or Mexican swine flu in 2009.

The One Health approach is also relevant to the SARS-CoV-2 virus-caused Covid-19 pandemic. The virus originated in animals, subsequently leaped to humans, and then was able to jump back to animals, as shown by infections of millions of mink, which died or had to be culled. To a lesser extent, SARS-CoV-2 can also infect dogs and cats, and wild animals such as foxes, deer and mice, which must be considered as potential reservoirs in the strategy to control and hopefully eradicate Covid-19.

7. ***Education is key to combatting animal plagues.*** Highly contagious and virulent microorganisms that spread rapidly and can reach any corner of the globe within days or weeks cause food animal plagues. They represent a severe threat to millions of animals, the food supply of a large population of the world and the principal property of hundreds of thousands of families, mostly in rural areas.

Education of society of the destructive potential of food animal plagues, and the way they spread, is crucial to the institution of efficacious practices that interrupt transmission chains and reduce the spread of plagues from animals to animals and from animals to humans, where they can adapt and cause most devastating epidemics and pandemics.

Relevance for Sustainable Development Goals and Grand Challenges

- **Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture** (*end hunger and malnutrition, increase agricultural productivity)*. The food animal plagues significantly reduce the yields of food animal meat and thereby increase meat costs and reduce accessibility to impoverished people. More effective

control of the food animal plagues would increase meat availability and food security, and reduce hunger.

- **Goal 3. Ensure healthy lives and promote well-being for all at all ages** (*improve health, reduce preventable disease and premature deaths).* Adequate healthy nutrition is essential for good health, so undernourishment promotes poor health. Food animal plagues significantly reduce the yields of food animal meat and thereby increase meat costs and reduce accessibility to impoverished people who as a consequence, become undernourished. Some food animal diseases affect exposed humans, i.e. are zoonotic, and so result in human infections. More effective control of the food animal plagues would reduce both malnutrition-caused ill health and human infections.

Potential Implications for Decisions

1. ***Individual***
   - **a.** What should we eat tonight?
   - **b.** When we go out for a walk and see some pigs or chickens in a farm, should we try to get them to come to us by offering them some of our picnic sandwiches? (Why not?)
   - **c.** If we hear about a local outbreak of an animal plague, should we go to an affected farm to check if the animals are okay? (Why not?)

2. ***Community policies***
   - ***a.*** Education campaigns to raise awareness of human transmission of farm animal plagues
   - ***b.*** Effective notices warning people away from infected farms and access paths/roads

3. ***National policies***
   - **a.** Animal health protection policies
   - b. National epidemic outbreak response plans and logistics

Pupil Participation

1. ***Class discussion of the issues associated with food animal plagues***

2. ***Pupil stakeholder awareness***

a. Eating meat has positive and negative consequences for the SDGs. Which of these are most important to you personally/as a class?

b. Can you think of anything that might be done to reduce the negative consequences?

c. Can you think of anything farmers might do to reduce the environmental footprint of animal food rearing?

The Evidence Base, Further Reading and Teaching Aids

BBC News (2019) "Largest world stock of animal-killing virus destroyed by UK lab". https://www.bbc.com/news/science-environment-48629469

Claas EC, Osterhaus AD, van Beek R, De Jong JC, Rimmelzwaan GF, Senne DA, Krauss S, Shortridge KF, Webster RG (1998) Human influenza A H5N1 virus related to a highly pathogenic avian influenza virus. Lancet 351:472–477

FAO (2011) The Global Rinderpest Eradication Programme. Progress report on rinderpest eradication: Success stories and actions leading to the June 2011 Global Declaration. http://www.fao.org/ag/againfo/resources/documents/AH/GREP_flyer.pdf
FAO (2013) World Livestock 2013: changing disease landscapes. http://www.fao.org/3/i3440e/i3440e.pdf
FAO (2020) Animal Production and Health, ASF situation in Asia, update. http://www.fao.org/ag/againfo/programmes/en/empres/ASF/Situation_update.html
Gilbert N. (2009) Cattle disease faces total wipeout. Nature 462:709, doi:10.1038/462709a.
Knight-Jones, T. J.; Rushton, J (2013). The economic impacts of foot and mouth disease – What are tey, how big are they and where do they occur? Preventive Veterinary Medicine 112:161-173. doi:10.1016/j.prevetmed.2013.07.013
McNeil, D.G (2011). "Rinderpest, a Centuries-Old Animal Disease, Is Eradicated". The New York Times. https://www.nytimes.com/2011/06/28/health/28rinderpest.html?pagewanted=all
Normile D. (2008) Driven to Extinction. Science 319:1606-1609.
OIE (2011) "No More Deaths From Rinderpest" (Press release). World Organisation for Animal Health. Retrieved 25 May 2011.
OIE (2020a) Office International des Epizooties, terrestrial animal health code https://www.oie.int/doc/ged/D13953.PDF
OIE (2020b) OlE listed diseases, infections and infestations in force in 2020. https://www.oie.int/en/animal-health-in-the-world/oie-listed-diseases-2020/