Chapter V: Dynamics of biological diversity and health implications

Humans are an integral part of biological diversity. Wild fauna and flora constitute a natural reservoir and means of dispersion for a large variety of parasites, some of which are pathogenic and may be transmitted to domestic species or human populations.

V.1 The Complexity of Host–Parasite relationships

Humans, like other mammals, harbor numerous parasites. Very often, the biological cycle of these parasites involves at least two hosts: a definitive host and one or several intermediate hosts in which a part of their life cycle is completed. These intermediate hosts transmit the parasite to humans: mosquitoes are the vectors of malaria, blackflies of onchocerciasis, cats of toxoplasmosis, etc.

The transmission mechanism of vector-borne diseases constitutes excellent examples of functional biodiversity because it involves three types of actors: a vector, a pathogenic agent, and a host.

Research on the epidemiology of parasitic diseases requires solid taxonomic knowledge at two levels:

- for the morphological identification of vectors and reservoirs of diseases, which may be either vertebrates or invertebrates;
- for the cytogenetic or genetic identification of the different “strains” of vectors or pathogens involved. It is becoming increasingly clear that small genetic variations can have major consequences on the capacity for transmission or pathogenicity of parasitic species.

Example: The Case of Malaria

Malaria is one of the deadliest diseases on the planet: each year it affects hundreds of millions of human beings and causes more than 2 million deaths. The pathogenic agent is a protozoan of the genus *Plasmodium*, transmitted by mosquitoes of the genus *Anopheles*, several species of which are pathogenic to humans.

In Africa, five species of anopheles are effective vectors: *A. gambiae*, *A. arabiensis*, *A. funestus*, *A. nili*, and *A. moucheti*. However, there are also 8 or 9 other species that serve as local or secondary vectors. It follows that several agents are likely to transmit malaria in the same area, sometimes simultaneously, sometimes during different seasons.

V.2 Emerging pathologies

Viral and bacterial infections have long been the main cause of human mortality. The influenza pandemic that occurred between 1918 and 1919 (the Spanish flu) killed between 20 and 40 million people more than the First World War. With progress in hygiene and vaccination, this type of mortality declined considerably, to the point where it was hoped that infectious diseases were on the verge of being solved.

However, this trend has reversed over the last decade. Ancient diseases are reappearing and spreading into new areas, sometimes due to pathogen resistance to drugs. This is the case for malaria, tuberculosis, yellow fever, and cholera. The emergence of treatment-resistant forms, linked to increasing urbanization, has contributed to the resurgence of tuberculosis, which killed 3 million people in 1995.

In addition to old infectious diseases, which remain a significant cause of mortality, new illnesses never described before are appearing around the world and claim numerous victims. These new diseases are called emerging diseases. About thirty of them have been identified since the early 1970s. For example, hepatitis C, whose virus was identified in 1989, causes tens of thousands of deaths each year. The same applies to HIV/AIDS, the Ebola virus, Lyme disease, and the coronavirus, among others.

Therefore, emerging diseases are caused by pathogens that have long been present in the environment but have recently entered human populations, originating from another species, as a result of environmental changes that increased the likelihood of contact.

V.3 Environmental change, biological diversity, and Human health

Environmental changes are responsible for the emergence or development of numerous diseases affecting human populations. It should be noted that these changes are largely due to human activities, as humans alter the physical and biological characteristics of their environment.

The expansion of irrigated perimeters and the filling of reservoirs promote the proliferation of vectors such as mosquitoes and mollusks. The growth of the global population and the occupation of new territories increase the probability of contact between humans and vector species carrying pathogenic organisms, as well as lifestyle changes.

International trade and widespread intercontinental exchanges lead to the dissemination of pathogens (viruses, bacteria, fungi, protozoa, and parasites) and their vectors or potential reservoirs.

The introduction of new technologies is also responsible for putting humans into contact with microorganisms that previously did not affect us.

In the food sector, changes in consumer behavior have led to the emergence of new diseases or, at least, the return of rare diseases known for a long time.

The eutrophication of water bodies and the proliferation of toxic algae produce toxins that can cause mass mortalities in marine fauna and sometimes fatal poisoning in humans.

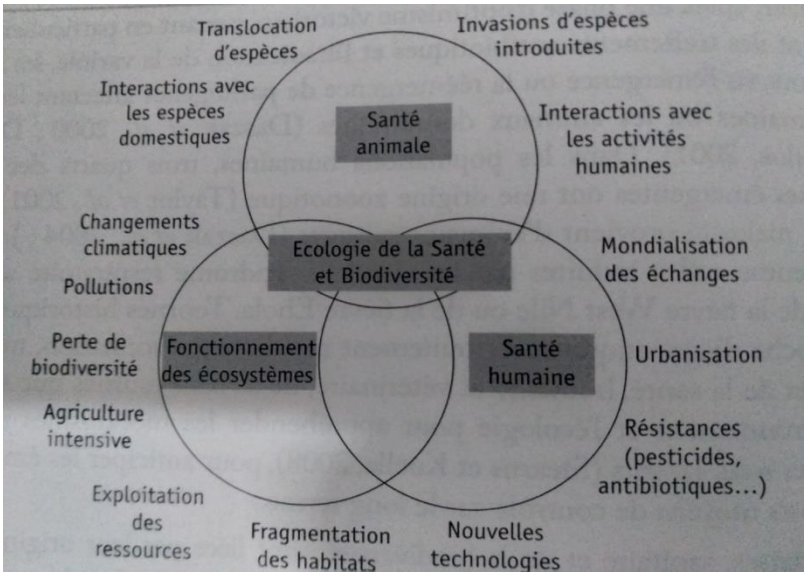

Figure 12: Interactions Between Human, Animal, and Plant Health, Ecosystem Health, and Environmental Disturbances.

Allergy, which is often a pathological expression of anaphylaxis, appears as an immediate hypersensitivity because the reactional effect occurs within minutes following stimulation.

Pneumoallergens, responsible for respiratory sensitization, have various origins:

- The main sources are grass and tree pollens. The introduction of plants originating from other continents can increase the risks of allergic reactions.
- Mites of the genus *Dermatophagoides* constitute the main source of allergies in household dust and are responsible for the majority of allergenic asthma cases. Mattresses are their true ecological niche, but they are also found in carpets and rugs, as well as in stored food products. Modern lifestyles have, to a certain extent, benefited mites.

V.4 The Growing impact of viral diseases

Infectious diseases testify to the relationship between humans and their environment and to the reproductive strategies of pathogenic microorganisms that find in humans a suitable host. The increase in human population, as well as the multiplication of contacts with other animals, creates favorable conditions for some microorganisms to choose humans as a preferred host. The emergence of new viruses, particularly those causing hemorrhagic fevers such as the Ebola virus or the dengue virus, or even HIV, is a growing concern for public health services.

On the one hand, viruses given their rapid life cycle have the ability to adapt very quickly to environmental changes compared to humans and other animals with longer life spans. The emergence of a virus may therefore result from the evolution of a new viral variant following mutations or recombinations between existing viruses, which can produce more virulent strains.

On the other hand, it is likely that certain viruses that have long existed in the environment, within certain animal species, suddenly emerge as a result of environmental changes. Thus, deforestation for the creation of agricultural land facilitates the multiplication of rodents, which often serve as animal reservoirs for viruses, and the construction of dams favors the proliferation of mosquitoes, which are vectors of numerous pathogens.

V.5 Adaptation of pathogenic agents and their vectors to control measures

Humans have developed strategies to combat diseases, but pathogens have deployed a range of strategies that allow them to survive these control measures.

V.5.1 Antibiotic resistance

In 1941, less than 1% of *Staphylococcus aureus* strains were resistant to penicillin. By 1994, 90% of the strains had become resistant.

V.5.2 Resistance to pesticides

This resistance depends on several factors:

- mutation (alleles responsible for resistance),
- selection, which favors individuals carrying genes best adapted to environmental conditions,
- migration and colonization of new areas.

V.6 Medically relevant substances and biological diversity

For economic reasons, about 80% of humans still do not have access to modern medicine and rely on traditional medicine, which often uses medicinal plants. Although around 20,000 plant species are used worldwide in traditional medicine, only 5,000 have been studied as potential sources of pharmaceutical substances.

Various animal products are also used in traditional medicine, even though the active principles are not truly understood. Rhinoceros horn or tiger bones are examples, although their effectiveness remains unproven. Animals are also the source of pharmacological substances. Shark liver contains compounds that increase the resistance of the human body to cancerous conditions. Bee venom is used in treating arthritis, and venom from many snakes is used in pharmacology.

Genetically modified organisms (GMOs) have been used on a large scale since the late 1970s to produce medications. (Insulin is mainly derived from genetically modified bacteria).