Chapter 6 Conflicts in livestock-wildlife interaction (health aspects and predatory behavior)

Capítulo 6 Conflictos en la interacción ganadería-fauna silvestre (aspectos sanitarios y conducta predatoria)

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DOI: 10.35429/H.2022.1.90.105

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N. Niño, M. Valencia and M. García. (AA. VV.) Sustainability, Rurality and Society. Handbooks-TIV-©ECORFAN-Mexico, Guerrero, 2022.

Abstract

The main aim of this chapter is to provide a basic understanding of the conflicts that arise when livestock and wildlife interact. The access granted by the Autonomous University of Campeche to databases such as Science Direct, Springer Link, Ebsco Host and Google Scholar was used. To achieve this objective, the text was divided into two parts. The first part deals with the generalities of livestock predation by wildlife, addressing conflicts mainly with carnivores and existing strategies to reduce encounters between these animal populations. The second part deals with the health interface between livestock and wildlife, where emphasis is placed on the importance of studying diseases in wild animal populations, as they are reservoirs of etiological agents that cause diseases in livestock as well as humans.

Livestock-wildlife interaction, Livestock predation, Livestock-wildlife health interface

1. Introduction

Human-wildlife conflict is defined as any interaction between them that results in negative impacts on human social, economic, or cultural life, wildlife conservation, or the environment. It occurs when humans or wildlife are having an adverse impact on the other. These conflicts have occurred since the dawn of humanity, they occur on all continents, both in developed and developing countries (IUCN, 2005). The biggest challenge in many countries is the growth of the human population and its settlements close to nature reserves, where the conflict becomes more intense where livestock and agriculture are an important part of the livelihoods of the population.

According to the Worldwide Fund for Nature (WWF), the human population is expanding, and nature reserves are dwindling, people and animals are increasingly coming into conflict over living space and food. They are also causes of conflicts, the development of infrastructure, urbanization, and climate change. Some types of conflicts are, for example: i) Destruction of crops by elephants, primates, birds, hippopotamuses, and rodents; ii) Attacks on livestock by part of big cats, hyenas, wolves, and feral dogs; iii) Deaths and injuries to humans by crocodiles, tigers, bears, big cats and hippopotamuses; iv) Driving accidents caused by deer, antelope, elk, coyotes and wild boar; v) Transmission of zoonotic diseases by primates, rodents, wild boars, birds, foxes and deer. These conflicts between humans and wildlife require strategies to favor coexistence and mitigate the consequences for human health, safety, and well-being, as well as to maintain biodiversity and ecosystem health (Nyhus, 2016). A prerequisite for finding effective solutions is understanding the details, mechanisms, and nature of the conflict.

Therefore, the objective of this work is to describe two types of conflicts in the wildlife-livestock interface; the first section describes the origin, scope and strategies that have been developed to mitigate the problem related to livestock predation and the second section will establish a review on the transmission of zoonotic diseases by wildlife, especially large mammals, in addition to both problems some management strategies are identified that promote food security, resource conservation and rural development.

2. Methodology

A search was carried out in the databases provided by the Autonomous University of Campeche through CONRICyT such as Science Direct, Springer Link, Ebsco Host and Google Scholar search engine using as keywords: livestock and wildlife interaction, depredation of livestock, conflicts with carnivorous animals, strategies to decrease predator/livestock conflict, livestock/wildlife health interface: brucellosis, tuberculosis, whit the purpose of describing the origin, scope and strategies that have been developed to mitigate the problem and promote food security.

3. Result

There are many articles on the established topics and those that best explain the conflict and strategies on livestock and wildlife, as well as its effect on the health of livestock was selected. Each section was explained based on previous studies and reviews on the subject.

4. Depredation of livestock

4.1. Livestock production

Livestock is an economic activity of very ancient origins that consists of the management of domesticable animals for their use with productive purposes. Due to population growth and rising incomes in many developing countries, there has been a dramatic expansion of the livestock sector globally in recent decades. In developing countries, annual *per capita* meat consumption has doubled from 14 kg in 1980 to 28 kg in 2012. In the same period, total meat consumption tripled, from 47 to 137 million tons. Milk consumption for the period described doubled from 114 to 222 million tons. The analysis of the data indicates that the trend will continue for about ten or twenty years before its growth slows down (Alexandratos and Bruinsma, 2012).

There are more than 4.2 billion cattle, sheep, goats and pigs grazing on 30% of the planet earth's surface and in some regions, overgrazing has reduced the density and biomass of plant and animal species altering ecological succession, nutrient cycling and landscape alteration (FAO, 2018). Of course, this high livestock production demands a large amount of food resources such as forage and grains, among others, to sustain the supply of meat and milk. The production of these food resources has had an impact on the use of the land, where the areas of crops and pastures have increased with the detriment of forests and jungles. The conversion of natural habitats to pasture or cropland has been a rapidly growing trend since 1850 (Klein-Goldweijk and Battjes, 1997). This conversion in land use and its growing expansion within natural ecosystems implies a loss of biodiversity and exerts great pressure on the populations of wild animals, wild or free-living.

4.2. Livestock and wildlife interaction

Livestock production and wildlife are part of a socio-ecological system (Biggs *et al*., 2015) in which the activities of humans determine the interactions between them, inducing conflicts. The impacts of these interactions can be direct, because of the physical presence of livestock on shared pastures, or indirectly through the changes they create in the vegetation. These changes can be primary influences such as: herb removal or trampling; and higher order effects such as: changes in structure, productivity, or composition of the vegetation (Kauffman and Pyke, 2001). Changes in vegetation created by farm owners will influence wildlife through factors such as quality and quantity of food, cover from predators, or availability of nesting sites. It can also have cascading effects through a food chain by altering prey abundance for higher trophic levels. However, there are numerous reports that attest that controlled coexistence between domestic livestock and wildlife is possible, especially in interaction with wild herbivores such as large ungulates.

4.3. Improved forage quality

The improvement of forage quality occurs indirectly when grazing with domestic cattle at certain times of the year eliminates mature vegetation, resulting in higher biomass and availability of tender forage in the following seasons. Anderson and Scherzinger (1975) found a relationship between increased moose populations and cattle grazing on common grasslands. The authors hypothesized that proper spring grazing of cattle during the active growth stage of pastures delays pasture maturity, allows regrowth, and thus increases pasture availability and quality in fall-winter, a time when the number of moose increased in these grasslands.

Austin and Urness (1986) showed that the crude protein values of deer diets in pastures where there was previous grazing or not by cattle did not differ significantly, as did in vitro digestibility, which confirms that previous grazing of livestock in areas where deer still feed does not affect nutrient availability. In the same study they found that the influence of cattle grazing, and the deer was a function of grazing intensity. Higher intensity has more impact on the vegetation consumed by deer by altering the diet in favors of other species and grasses, however, neither the crude protein or the *in vitro* digestibility was affected in the deer diets. Here the strategy is to control the stocking rate of the cattle to find a balance and not affect the availability of food for the deer.

4.4. Conflicts with carnivorous animals

The predation of livestock by large carnivores is common throughout the world; the destruction of wild habitats by population growth has resulted in the decline of populations and even extinction of several species of carnivores (Farris *et al*., 2015). Due to the above, there is a strong antagonism and a deep-rooted hostility against wild predators. The main causes of the conflict have already been mentioned and are the growth of the human population and its settlement in areas where wildlife lives and the deterioration of the habitat and decrease in the prey available to predators.

The above factors increase the overlap between wild carnivores, livestock, and humans, increasing the chances of encounters and therefore of conflicts. In the world, the main problem is the depredation of livestock by wild carnivores (Rosas-Rosas *et al*., 2008; Kaartinen *et al*., 2009), since it causes economic losses to the rural population, calculated between $95.6 (Kebede *et al*., 2022) and $134,253 dollars (Peña-Mondragón and Castillo, 2013), or 12% of the net income of a household (Butler, 2000). According the International Union for Conservation of Nature and Natural, variations depend on the country, type of livestock depredated (sheep, cattle, horses, poultry) and predator (hyenas, jaguars, lions, leopards, bears, great eagles), the latter being perceived as threats that often result in retaliation against the species considered guilty, which causes conflicts between conservationists and producer about what should be done to resolve said situation (IUCN, 2020), in addition there are other costs such as fear, avoidance behaviors and the threat to human life (Jacobsen *et al.*, 2022).

This psychological dimension of damage by predators is truly important, especially for the design of strategies for managing the conflict of predation on large and small livestock, because together they influence human responses to these losses (Kellert, 1985). However, these attitudes toward predators are not determined by any direct cost imposed, but rather are the product of a dynamic and complex web of individual, social, and cultural factors (Dickman *et al.*, 2013). Thus, the way in which this conflict is managed has consequences for the conservation of large carnivores and biodiversity, since several of the wild predatory species reported are in some category of important risk in terms of conservation of species (Table 1). In some cases, various strategies have been designed to mitigate and/or avoid this conflict and its detriment to the wild species involved.

Table 1 Predatory wild species and their category of extinction risk

Species	Country or continent of origin	Risk Category*
Lycaon pictus	Africa	Endangered
Spizaetus isidori	South America	Endangered
panthera tigris	Asia	Endangered
panthera pardus	Asia/Africa	Vulnerable
Panthera leo	Africa	Vulnerable
Panthera uncia	Asia	Vulnerable
Panthera Onca	America	Near threatened
Leopardus wiedii	America	Near threatened
canis lupus	Cosmopolitan	Minor concern
cougar concolor	America	Minor concern
Crocuta crocuta	Africa	Minor concern
Canis latrans	America	Minor concern
Ursus americanus	America	Minor concern
Lynx spp .	America, Asia, Europe	Least Concern except the Iberian lynx (*Lynx pardinus*) which is Endangered
Leopardus pardalis	America	Minor concern
Puma yagouaroundi	America	Minor concern

Data Taken from IUCN: https://www.iucnredlist.org/

These attacks on livestock of course bring with them an economic problem due to the loss of the animal, so that persons must make decisions and actions that prevent this depredation.

It is suggested, for example, night confinement of cattle, installation of fences, putting watering holes for fauna, adjusting the animal load to prevent cattle from walking towards the edges of the forest or jungle that leads to encounters with predators, avoid disposing of carcasses in the forest or jungle so that predators do not get used to consuming meat from domestic animals. It is suggested not to hunt these predators as they play an important role in controlling other species.

4.5. Strategies to decrease predator/livestock conflict

The IUCN has a specific advisory group called the HWCTF (Human-Wildlife Conflicts Task Force) by providing resources, training, and interdisciplinary guidance. However, the same organization recognizes that the efforts to reduce the conflict are not yet significant (Gross *et al.*, 2021). In this regard, several investigations have been carried out to identify errors in the implementation of predation control strategies, which are detailed below.

Control by killing (lethal control)

Lethal control is one of the main ways to deal with conflicts with large carnivores, both illegally and legally, with some governments carrying out or supporting population culls or targeted killings of problem individuals. Lethal control strategy is readily available and is perceived to be cheaper, more practical, and effective than non-lethal methods. For example, a recent study conducted on a group of ranchers in Wyoming, United States, found that lethal mitigation strategies were perceived as more effective than non-lethal mitigation strategies, this result differed depending on the predator species in question (Scasta *et al*., 2017).

Such a perception can be explained because killing the predators may be perceived as effective due to the benefits for a small minority of farmers, and even worse if the neighbors experience the secondary effects of the lethal intervention, such as displaced predations, they may perceive that the problem grows and then it requires a more lethal intervention, which causes a vicious circle (Santiago-Ávila *et al.*, 2018).

The great disadvantage of this method is that by killing predators, their social groups are fragmented, which makes them disperse more and attack other localities, or ecological niches are vacated that allow the establishment of smaller and more numerous predatory species that still consume livestock (Treves *et al.*, 2016). In addition, killing predators that occasionally feed on livestock has raised concerns associated with ethical issues and ecological impacts as declining populations of large-bodied predators have led to ecosystem degradation and the disruption of vital ecological processes. important for life on this planet (Ripple *et al.*, 2014). For these reasons, non-lethal control strategies have been developed for these species.

Non-lethal predator control strategies

There are aversive and dissuasive techniques, which consider changes in the behavior of animals through learning. Aversive conditioning relates a negative experience to a particular behavior, and deterrent conditioning interrupts the predator's behavior through mechanisms such as neophobia or pain (Zarco and Monroy, 2014). These strategies seek to reduce predation, with the additional benefits of a favorable public perception by promoting animal welfare of both predators and prey and reducing lethal incidences on non-target animals, being methods more compatible with conservation of species and less probability of triggering ecological disturbance effects (McManus, 2015). These strategies include:

Carnivore deterrents: These are physical objects and sensory stimuli that interrupt specific elements of carnivorous behavior or act on ecological aspects of the predator (Wilkinson *et al.*, 2020). As an example, there is the use of the so-called fladry which is a visual barrier used to scare away wolves and coyotes and even wild boars, whose foundation is the neophobic behavior of wolves. It consists of a strand of polywire with plastic flags attached and arranged at a similar distance between them of 40 or 60 cm, although 30 or 45 cm is more recommended. There is also the turbo fladry (electrified wire) and others with materials such as nylon or vinyl and making special knots and increasing the current standard length.

They are recommended as a temporary dissuasive measure, coinciding with the calving period, to avoid attacks in the most sensitive times. Studies carried out in the United States indicate that the fladry is useful for a period of 23 to 157 days. For greater effectiveness, it is recommended to combine it with other methods of livestock protection and consider habituation by predators, so it should be used only temporarily (Figure 1) (Iliopoulos *et al*., 2019, Young *et al*., 2019).

Figure 1 Fladry is a line of flags, or a rope mounted along the top of a fence, from which are hung strips of cloth or colored flags that are intended to deter wolves from crossing the line

Credit Ian McGregor, Oregon State University Service Livestock. https://ourimpact.oregonstate.edu/story/livestock-producers-embrace-progressive-tactics-dealing-wolves

Flashing Light Deterrents: This technique involves placing light devices at each end of an imaginary ellipse surrounding the cattle sleeping area, these devices continuously emit flashing lights that vary randomly and turn on at dusk as light levels decrease and turn off at dawn in response to increased light levels. It is effective against predation by cougars and other predators (Wanjira *et al*., 2021).

Acoustic deterrents: These include all types of sound-producing devices from shouting, clapping, and a variety of home-made and commercially-produced noise-making devices (rattles, can-rattles, vehicle horns or sirens, and/or whistles), as well as sounds of recorded animals and recordings of human voices, of gunshots, use of radios, devices that produce loud explosive sounds such as discharges or of firearms projectiles or other explosives or sound generators, to take advantage of the tendency of wild animals to fear/avoid to humans, ultrasound is also included. Acoustic and visual aversive devices are often used in combination as they are more successful than when used alone (Wilkinson *et al*., 2020).

Chemical repellents or conditioned prey aversion: These are chemical substances such as capsaicin, cinnamaldehyde, uiidecenovannillylamina, derivatives of coal tar and other chemical products that are used on prey animals in the form of pour-ons or in collars, preventing the predator from approach the animals. The chemicals are placed on the prey to produce an unpleasant adverse effect such as vomiting, nausea and/or diarrhea in the predator, so that the predator learns to reject this prey in subsequent encounters by associating it with a taste or smell that makes them uncomfortable. The disadvantage is that predators end up getting used to these repellents so, like the previous aversives, they must be used randomly (Wilbanks, 1995).

Livestock Protection Animals: Since 1970, dogs have been used as livestock guardians in the United States. The disadvantage of using these animals is that they can sometimes be aggressive towards people, they can start to disturb the animals they protect, and they are also subject to injury and death. On the other hand, since 1980 llamas have been used to protect small livestock from attacks by coyotes, foxes, and dogs with successful results. Donkeys through their behavior of braying, biting, running, chasing, and kicking the intruder have also been used to protect livestock.

The advantages of using animals against predation are the reduction or elimination of predation, reducing labor to confine sheep and goats at night, and efficient grazing (Andelt, 2004). The disadvantages of this strategy are the investments for the acquisition of animals, operating costs (food, health) and in the case of guard dogs, the legislation on handling dogs associated with their use (Eklund *et al*., 2017).

Predator removal: Refers to those techniques that reduce the number or change the demographics of carnivores to a defined area (Wilkinson *et al*., 2020). It can be of selective type, which consists of trapping the culprit predator or a group of predators of the species in question, and then it can be removed to take it to another area within its natural geographical distribution (translocation) or the animals can be humanely removed and even taken into captivity in zoos or sanctuaries (Smuts, 2008). However, the predator removal strategy has shown that it is only effective in the short term since a sustained suppression of predators is not generated, so it is recommended to identify the role of the predator within the ecosystem and the possible consequences of the elimination on animals, competitors and prey. On the other hand, the recorded translocations of animals show that the animals do not stay at the release site and even that the aggressiveness of the animals towards people increases, causing a great danger (Athreya *et al*., 2011).

Another predator removal strategy involves sterilization or contraception of predatory species. In this case, the reproduction of the "problem species" is avoided. The strategy has involved the development of various contraceptives and methods of administering these drugs. In this regard, it has been shown that in coyotes (*Canis latrans*) sterilization successfully reduces, but does not eliminate predation (Bromley and Gese, 2001). These types of strategies must also be evaluated, establishing the objective, proportion, and periodicity in which the population must be sterilized to achieve the goal of reducing the size of the predator population or to stop the growth of the population and thus achieve the desired reduction and reduce the harm to domestic animals.

Zootechnical management of livestock: It refers to all those activities that are carried out for the maintenance of healthy livestock and that research has shown to influence the probability of being preyed upon. These management strategies include:

a) Stocking rate, which is the amount of land allocated to each animal during the entire grazing part of the year, and which differs between zones by climate (annual rainfall) and vegetation, animal species, size and physiological stage, size of the prairie or ranch and the number of hectares for grazing. The stocking rate supported by a system defines the general health of the environment and production (Lyons *et al.*, 2001).
b) Rotational grazing refers to the movement of cattle through a series of pastures or paddocks, preventing cattle from being more vulnerable to predation because they are dispersed over large areas (Barnes, 2015). Restricted grazing in which animals graze only for periods of time while being watched to ward it off predators is also recommended (Rollin, 2004).
c) The selection of livestock breeds since it has been observed that the phenotypic (color and size) and biological characteristics of livestock can favor predation (Khorozyan, *et al.*, 2018).
d) Construction of farrowing pens to minimize the risk of predation in the most vulnerable stage of the production species (Barnes, 2015).
e) The construction of pens to confine the cattle and thus avoid predation by carnivores. It is recommended to carry out this confinement at night, which is the time when most predatory attacks occur (Eklund *et al.*, 2017).
f) Use of fences to delimit the entrance of predators to the management site is a strategy that has been used since 1930 and better results are observed with the use of permanent or temporary electric fences, as well as the use of two electric mesh fences (Wyckoff *et al.*, 2016)

Land use and management of wild prey: It is a natural resource management approach that allows the separation of prey and livestock by altering habitats and/or making free-living prey available by:

a) Land use zoning guidelines. This strategy is successful in terms of separating livestock from carnivores through land use planning (Strand *et al.*, 2019).

b) Establishment of protected natural areas and buffer zones, which are part of the zoning principles to allow wildlife conservation and anthropogenic activities (Gurung *et al.*, 2009). Buffer zones are areas that are used to minimize the negative impacts of human settlements and their activities in protected areas (Wilkinson *et al.*, 2020).
c) Habitat enhancement for predators to occupy other areas of the landscape (Wilkinson *et al.*, 2020). This involves manipulating the habitat to favor prey species and thus decrease livestock predation and involves everything from vegetation thinning to subtle changes in grazing (Rollin, 2004).
d) Conditioned taste aversion consists of the use of food to divert the activity or behavior of a target species, without the intention of increasing the density of this population (predators), generally food is used to drive animals away from activities or places where they are causing problems (Rollin, 2004).
e) Use of food baits that consists of using another type of food to "distract" the predator, a strategy that can cause an increase in the number and concentration of predators in areas where there are cattle (Fernández-Arhex *et al.*, 2015).

Economic incentives: The financial mechanisms aim to reduce the economic loss that depredation generates for farmers, which is done with a compensation through direct payment to farmers for the livestock attacked by the carnivore. On the other hand, photographic tourism has been created that generates income for locals through tourists who pay to see wild animals. Both strategies have problems, since the first requires an expert opinion carried out by trained personnel to determine whether the death of the cattle was due to predation and even identify the predatory species involved (Oropeza-Hernández *et al.*, 2014). In this regard, research showed that the main problem with compensation incentive schemes is the lack of clarity regarding the equitable distribution of benefits and the lack of implementation with additional interventions such as: educating the public about the value of carnivores or how to use non-lethal methods to prevent predation. On the other hand, photographic tourism also requires the training of personnel who will serve tourists, organize the visit, design the viewing route, and establishments and infrastructure for hosting tourists (Drumm, 2004). It has even been observed that in cases where an ecotourism strategy has been used, the projects have not shown sufficient evidence of its usefulness in reducing threats to livestock or improving the status of the biodiversity it seeks to protect (Eshoo *et al.*, 2018). Currently, the commercial strategy of certification as "Predator-Friendly Beef" producer has been evaluated, this designation implies the production of meat on farms where predators are controlled through non-lethal strategies, which has been working since 2013. Bogezi *et al*., (2019) found that there are numerous barriers to its implementation, ranging from marketing problems to administrative and logistical barriers to socio-cultural implications, despite this it represents an opportunity to promote coexistence between livestock and predators. and could be adapted to local markets and cultures elsewhere.

Considerations

Recently, the strategies have been scientifically evaluated to demonstrate their feasibility. In this way, the implementation of good husbandry management practices for livestock is one of those considered to be of the first order (Reyna-Saenz *et al*., 2020). In this regard, due to the habituation behavior of predators to the strategies used, the use of fences (mainly electric) and the establishment of pens (lambing sheds) for birth control are the ones that have been most effective and long-lasting (Khorozyan and Waltert, 2019). It is also recommended to consider in the construction of enclosures and fences, the biology and behavior of the predatory species or species to be successful in preventing damage (Eklund *et al*., 2017).

Other strategies that have shown the efficient reduction of losses due to predation is the use of animals to protect livestock, followed by the effectiveness observed by the lethal control of animals. However, the latter is not compatible with wildlife conservation efforts, so its recommendation is discarded. Economic incentives have promoted tolerance of large carnivores in some localities and reduced retaliatory deaths (Van Eeden *et al*., 2018), so it is recommended that payment schemes be carefully executed, adapting to the individual situation to ensure that the desired conservation results are achieved through the satisfaction, economic and cultural needs of the people who bear the costs associated with the conservation and coexistence with wildlife (Dickman *et al*., 2011). It is also recommended to reconsider the importance of traditions, stories, and beliefs about the history of the community towards wildlife, as it opens opportunities for communities to develop awareness to live with a wild species (Gross *et al*., 2021).

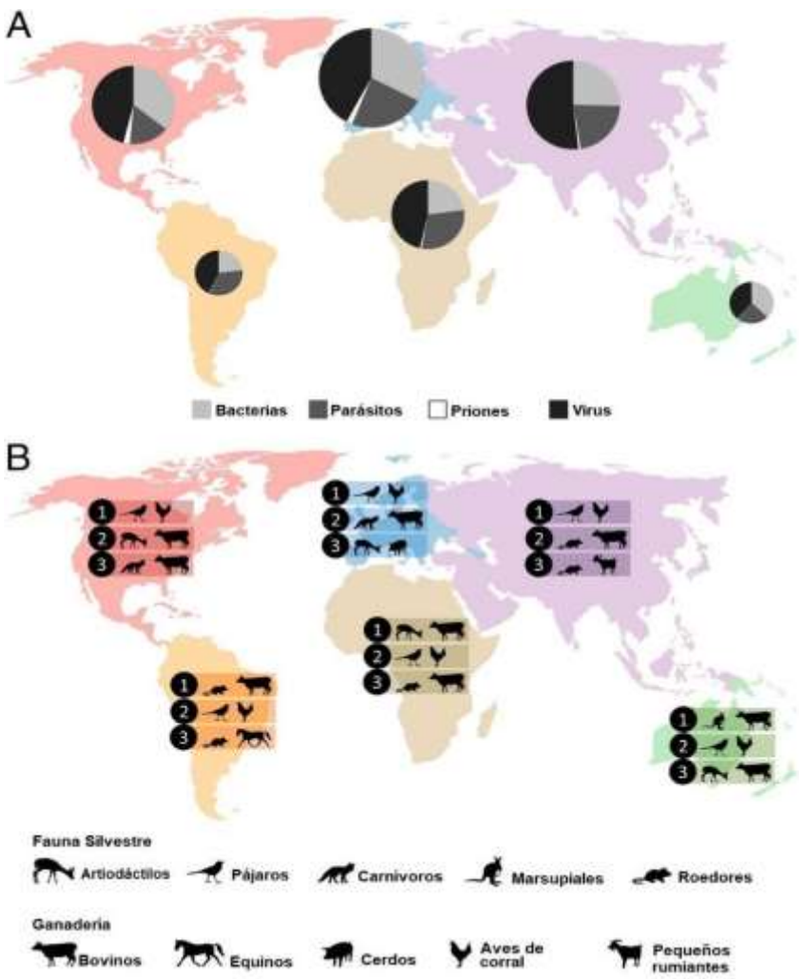
Is crucial in the successful implementation of strategies to control predation by carnivores, to consider the spatial differentiation of the environment (landscape, vegetation, climate) and the anthropic characteristics of the predation sites (social and cultural values), and the particularities of each region so that policies and strategies are oriented to the conditions and particularities of each locality, region or country (Reyna-Saenz *et al*., 2020); and establish routine monitoring for all intervention strategies used in specific areas and thus be able to make the relevant adjustments in time and that allow the coexistence of anthropogenic activities and conservation of species permanently.

5. Livestock/wildlife health interface

The changes in land use, from an ecosystem to an agroecosystem caused for example: by the intensification of livestock, agricultural intensification, deforestation, and invasion of virgin habitats, increases contact with wildlife. Thus, the transfer of diseases from domestic reservoirs to wild populations and vice versa is very important; and it is here that man is involved, since many diseases are zoonotic and anthropozoonotic (Daszak *et al*., 2000; Fischer and Gerhold, 2002).

The study of diseases of wild animal populations is a discipline that has developed extensively in recent years given their importance, proof of this are the more than 78,000 scientific articles published in the period from 1912 to 2013 (Figure 2) (Wiethoelter *et al*., 2015). In this study, it was determined that diseases that affect domestic cattle such as rabies, salmonellosis, tuberculosis, brucellosis, leptospirosis, and echinococcosis are among the first ten according to the number of publications (Table 2). However, it is considered tuberculosis and brucellosis as the most dangerous and important for including man in this interface (Cleaveland *et al*., 2001; Bengis *et al*., 2002; Miller *et al*., 2013).

Figure 2 Geographic distribution of pathogens (A), where the size of the circles is proportional to the number of publications obtained for the corresponding continent. Prominent interfaces between wildlife and livestock (B), showing the three main interfaces between wildlife and livestock reported by continent.



Taken from Wiethoelter et al., 2015.

Table 2. The three main interfaces between wildlife and livestock, including the predominant diseases

Wildlife	Type of livestock	Illness
Birds	Poultry	Poxvirus infections.
artiodactyls	Cattle	Bovine tuberculosis, brucellosis, malignant catarrhal fever, foot and mouth disease.
Carnivores	Cattle	Rabies, bovine tuberculosis, echinococcosis, leptospirosis, salmonellosis.

Taken from Wiethoelter et al., 2015.

At the international level there are organizations that are responsible for monitoring the diseases mentioned, this involves a multidisciplinary work involving veterinarians, epidemiologists, chemical laboratory workers, doctors, biologists, and other professionals. The World Organization for Animal Health (WHO) is in charge at a global level and in Mexico the National Service for Agri Food Health, Safety and Quality (SENASICA) is the organism in charge of sanitary control in wildlife. Tasks such as movement control, containment, protection of cattle with barriers, elimination of wild hosts, selective elimination of infected animals, reduction of risk factors such as vector control, treatments and vaccinations allow to have control of the diseases of domestic animals and therefore of public health.

5.1. *Brucellosis*

Brucella spp. are the etiologic agents of brucellosis, they are facultative, nonmotile, gram-negative intracellular coccobacilli that can infect a wide range of mammalian species, including humans, and some amphibians. In developing countries, *B. abortus*, *B. melitensis*, and *B. suis* are the main causes of animal and human brucellosis. Brucella animal infection can occur through multiple different routes. The most common is through the gastrointestinal tract, but conjunctiva or inhalation are possible, and spontaneous abortion in infected ruminants is the hallmark of infection. Fetal and placental tissues and associated fluids expelled in abortion events are the main way of transmission in animal populations (Nielsen and Duncan, 1990). The bacterium can reside in the environment for up to a year, depending on favorable conditions (moisture, soil composition, temperature, ultraviolet exposure, etc.) (Cheville *et al*., 1998). However, the presence of scavengers can reduce the time the bacteria remain in the environment. Of note, scavengers have not been recognized to increase the risk of transmission to livestock and scavengers are generally believed to reduce the risk of transmission (Cross *et al*., 2013).

The enormous challenges that remain to control and eradicate brucellosis are: (1) to develop and validate new diagnostics to replace culture, ideally an ante-mortem assay; (2) develop effective vaccines that provide better protection to animal populations and that comply with the differentiation between infected and vaccinated animals antibodies; and (3) address disease in natural animal reservoirs and dedicate resources to animal brucellosis management to reduce incidence in human populations, effectively applying a One Health framework (Hull and Schumaker, 2018).

5.2. *Tuberculosis*

Organisms of the *Mycobacterium tuberculosis* complex have been traditionally associated only with humans and domestic livestock. However, due to the improvement in molecular diagnosis and epidemiological techniques the detection of mycobacterial infection in new hosts has improved and is no longer considered solely a disease of humans and livestock and nowadays tuberculosis is considered has become established in the wildlife population (Miller and Olea-Popelka, 2013). There are several cases throughout the world of the livestock-human-wildlife interface, mainly in Africa and Asia, and fewer in Latin America. Political instability, fragmented public health infrastructures, diversion of health resources, inadequate tuberculosis control programs, and relatively high rates in certain Latin American countries all play a role in the continued presence of tuberculosis. Similar issues apply to tuberculosis programs for cattle (Cosivi *et al*., 1998)

Bovine tuberculosis is well documented in cattle herds in many Latin American countries and has the potential to spread to humans or wildlife through unpasteurized milk, contaminated meat, or environmental contamination. The environmental conditions, the potential interface with livestock and routes indirect transmission, such as carcasses or contaminated grass, are important factors when considering the risk of infection to wildlife. In Brazil, swamp deer (*Blastocerus dichotomus*) are giving negative results.

However, unlike ungulates, predators may be more at risk. Infected cattle could pose a threat to wild carnivores or scavengers through ingestion of infected meat or carrion or indirectly by eating insects which were in contact with infected secretions. There has been a report of a wild panther with tuberculosis from Argentina. In the mid-2000s in Argentina, carcasses of wild mink were found with lesions consistent with tuberculosis, which was later confirmed. The presence of the disease in wild mink poses a potential threat to disease control if wild and domestic animals share resources such as land or water (Miller and Olea-Popelka, 2013).

Miller *et al*., (2012) reported that a jaguar (*Panthera onca*) imported to a US zoo from Venezuela showed clinical signs consistent with tuberculosis and *Mycobacterium bovis* was cultured from samples taken at necropsy. This jaguar had come from an institution where whole carcass feeding was practiced, and ingestion of infected meat was likely the source of infection. For chronic infections such as tuberculosis, disease interface problems can cross international borders creating additional challenges.

As with brucellosis, tuberculosis at the livestock-human-wildlife interface should be studied in greater depth and solutions sought to control and eradicate the disease. Vaccination of livestock, control of wildlife and elimination of vectors are the great challenges ahead.

6. Conclusion

Livestock activity has a great impact on all components of the environment, it is already known that it affects the soil, water, atmosphere, and biodiversity. The destruction of wildlife habitat by the expansion of grasslands or croplands used to feed domestic livestock has led to proximity between wildlife and livestock. This closeness, known as interaction, has implications mainly for food and water competition, but also for the risk of diseases at the interface between domestic animals, wild animals, and humans, as well as cases of livestock predation by carnivores that have seen their natural preys decrease and to feed by attacking domestic livestock.

This coexistence can be an opportunity to increase the income of the producers by including wildlife in their production system, allowing them to use the grasslands of domestic cattle, promoting their reproduction to offer recreational services such as photographic safaris and controlled hunting. These producers would migrate towards a type of diversified livestock that in some way benefits the habitat of wildlife that for decades or centuries has been pressured and put in danger of its existence.

7. References

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