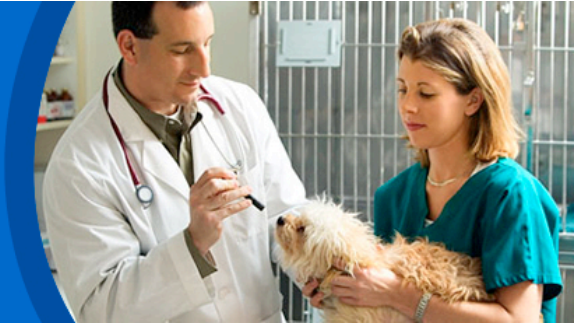




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Epidemiological trends of zoonotic diseases in animals notified through animal disease surveillance in Kerala from 2012 to 2021

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ABSTRACT

Zoonotic diseases are of great concern due to their impact on animal health, reproductive failure, and productivity. In humans, it can lead to morbidity and mortality with high potential for outbreaks as well as large impact on livelihoods and economies. The objective of the study was to describe the trend of zoonotic diseases among the animal populations in Kerala state from 2012- 2021 using animal disease surveillance data. A descriptive epidemiological design was used to describe the trend of zoonotic diseases notified in Kerala state setting from 2012-2021. Those diseases among animals with zoonotic potential for humans, and notified in the animal disease surveillance system like anthrax, brucellosis, leptospirosis, Newcastle disease, rabies, salmonellosis, and bovine tuberculosis among buffalo, cat, cattle, dog, duck, fowl, goat, pig, sheep, other birds species were considered in the study.

Newcastle disease comprised the majority of cases (297,402), followed by salmonellosis (16,170) and anthrax (407). Other reported burdens included rabies (3,379 cases), leptospirosis (940 cases), brucellosis (389 cases), and tuberculosis (249 cases). There is a general increasing linear trend in the notification of; brucellosis in cattle and goat species; leptospirosis in dogs, cattle and goat species; and rabies in dogs, Newcastle disease and salmonellosis among the fowl species and tuberculosis among the goat and cattle species.

Keywords: Zoonotic diseases, Surveillance, Trend, Epidemiology, Animals, Kerala

Introduction

Zoonoses or zoonotic diseases are those diseases and infections that are naturally transmissible between humans and vertebrate animals. The World Health Organization (WHO) estimates that globally there are around one billion cases of illnesses among humans and millions of deaths due to zoonoses every year (1). In a study by Jones *et al* published in the journal Nature, the incidence of emerging infectious diseases in humans have increased since the year 1940 and the majority (60.3%) are caused by zoonoses (2).

The World Organization for Animal Health (WOAH) envisages and implements the “One Health” approach for the prevention and control of zoonoses (3). The One Health approach is “an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems”. This approach identifies the interdependence and close linkage of humans, domestic and wild animals, plants and the environment on human health (4). Therefore, it is essential that we understand the disease dynamics and patterns in animals especially those of zoonotic potential. It is in this background that this study was envisaged with the objective to describe the epidemiological trend of zoonotic diseases among animals notified through the animal disease surveillance in Kerala from 2012-2021. The analytical framework helps understand the disease trends and risk factors and give valuable actionable points for public health authorities and policy makers.

2. Materials and Methods

This study utilized a descriptive epidemiological design set in Kerala state. Animal disease surveillance data for the period 2012-2021 was obtained from National Animal Disease Reporting System (NADRS/ later called as National Animal Disease Referral Expert System -NADRES), Directorate of Animal Husbandry, Government of Kerala. The system captures clinically confirmed animal disease cases at the village and veterinary hospital levels, escalating reports through the block and district tiers up to the state veterinary services directorate. It is also parallelly linked with the district diagnostic laboratories. Those diseases among animals with zoonotic potential and notified in the animal disease surveillance in Kerala state from 2012 to 2021 were taken into consideration in this study. They were Newcastle disease (Ranikhet disease), salmonel

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losis, anthrax, rabies, leptospirosis, brucellosis, and tuberculosis in animals. The species of animals studied were cattle, goat, sheep, buffalo, dog, cat, pig, fowl, duck, other birds and other animals. The Guidelines for Accurate and Transparent Health Estimates (GATHER) were followed (5). Data was extracted onto a data extraction tool developed on MS Excel and analyzed using MS Excel and R program. Ethics approval was obtained from the Ethics committee of the institution before the start of the study (SCTIMST -IEC/1893, dated 24.08.2022).

3. Results and Discussion

The animal species and groups that were studied from the animal disease surveillance are cattle, buffalo, goat, sheep, dog, cat, pig, fowl, duck, other birds, other animals. All seven zoonotic diseases were notified across all ten years studied, in at least one of the species listed. The disease wise summary of cases notified among animals are summarized in table. 1.0. The majority of diseases among animals notified were Newcastle disease (297402 cases) followed by salmonellosis (16170 cases) . There were 3379 cases of rabies, 940 cases of leptospirosis, 407 cases of anthrax, 389 cases of brucellosis and 249 tuberculosis in animals (Table 1).

Table 1. Disease-wise number of cases in animals notified through animal disease surveillance in Kerala from 2012-2021

Disease	Number of Cases
Anthrax	407
<i>Brucella</i>	389
Leptospirosis	940
Rabies	3379
Newcastle Disease	297402
Salmonellosis	16170
Tuberculosis among animals	249

3.1 Anthrax

Anthrax is an old zoonotic disease caused by the spore forming bacterium *Bacillus anthracis*, that predominantly affects herbivores but can also infect humans. This is a significant public health problem in low- and middle-income countries. Though it is a naturally occurring organism, it's lethality may be used as a biological weapon (6).

A total of 407 cases of Anthrax were notified among the animal species in Kerala from 2012-2021. The maximum number of cases was in the year 2013, 144 cases (35.4%), followed by 2014, 110 cases

(27.0%). Almost all of the cases were reported among cattle, the other being buffalo (4 cases in the year 2013). There were major outbreaks in the years 2013, 2014 and 2015 followed by minor outbreaks in 2018 and 2019. Overall, there is a decreasing linear trend in the notification of anthrax among animals in the state during the time period studied. The threat of anthrax will continue as the primary reservoir of the agent is the soil in the environment. Early identification of anthrax among the animals is required for the prompt control of the spread of the disease.

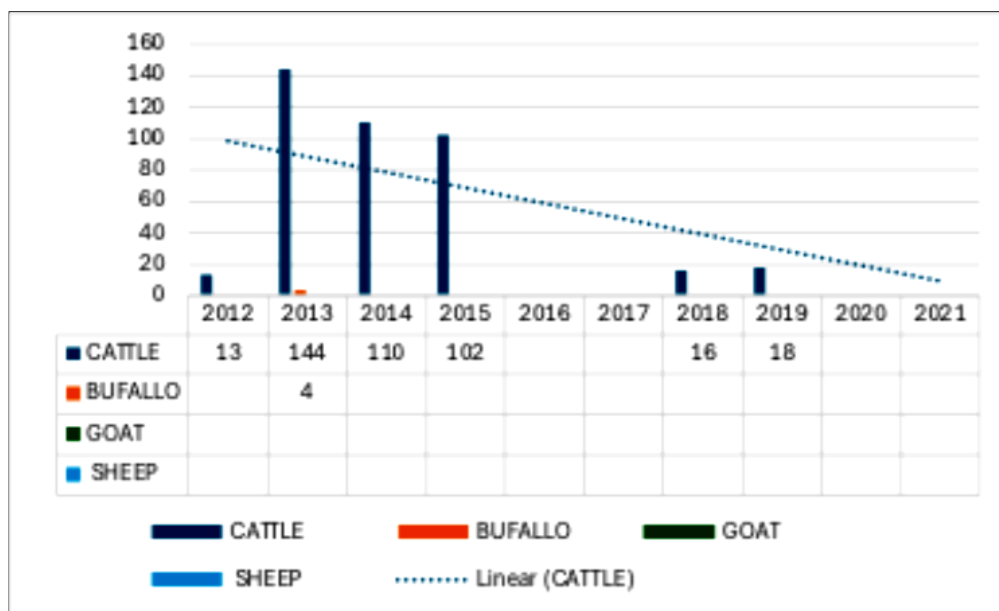


Figure 1. Notified cases of anthrax among animal species in Kerala from 2012 to 2021

3.2 Brucellosis

Brucellosis is a zoonosis and the infection is almost invariably transmitted to people by direct or indirect contact with infected animals or their products.

A total of 389 cases of Brucellosis were notified among the animal species in Kerala from 2012-2021. Half of all reported cases ($n = 196$, 50.4%) occurred in 2020. There was an outbreak of brucellosis outbreak among pigs ($n = 100$) in the year 2020, the emergence of which

indicates a possible expansion of the host range of the disease in the state. Cattle were the only species in which brucellosis was consistently reported throughout all ten years of the study period. Trend analysis showed that the incidence of brucellosis in cattle remained relatively stable over time, whereas cases among goats demonstrated an increasing trend (Fig.2). According to the WHO and WOA, managing brucellosis demands collaboration between human and animal health sectors and this partnership ultimately strengthens healthcare, food safety, and farming infrastructure (7).

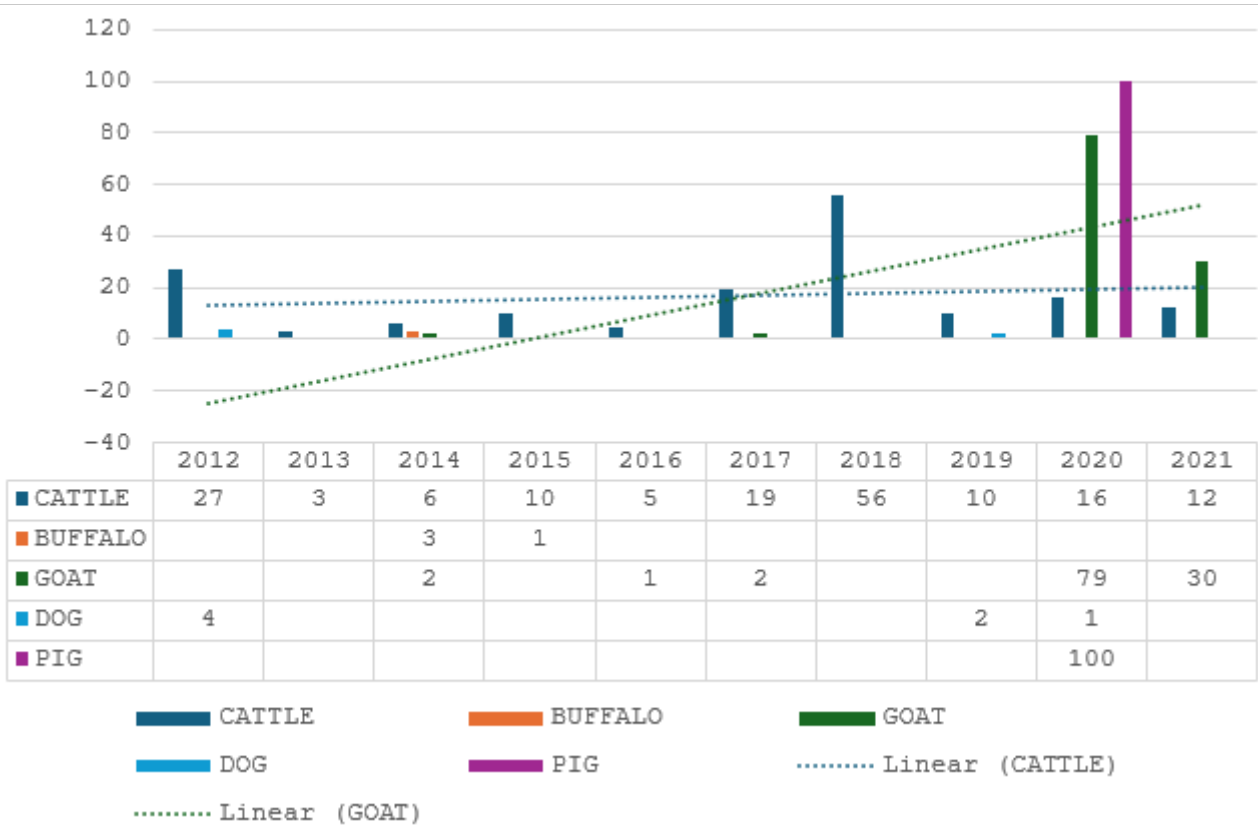


Figure 2. Notified cases of Brucellosis among animal species in Kerala from 2012-2021

3.3 Leptospirosis

There were 1018 cases of Leptospirosis notified in Kerala from 2012-2021. The most common species involved were the dog species 634 (62.3%), followed by cattle 154 (15.1%) and goat 100 (9.8%). Although cats are generally considered relatively resistant to leptospirosis, cases were also notified among them during the study period. For many years cats were thought to have been naturally resistant to leptospirosis because of minimal clinical presentation and the acidity of the urine, but PCR techniques have demonstrated the shedding of leptospira in urine by cats. A metanalysis of leptospiral infection in domestic cats by Ricardo (8) *et al* has concluded that domestic

cats should be considered as potential leptospira carriers and this information should also be used while designing public health strategies for the control of leptospirosis. The trend analysis demonstrated increase in leptospirosis cases among the dog, cattle and goat species (Fig.3). Importantly, leptospirosis was reported in all major domestic and companion animal species that are in close contact with humans. This finding has significant implications for the epidemiology and control of human leptospirosis. The Pan American Health Organization (PAHO) describes leptospirosis as a problem of human and veterinary public health as leptospira strains can establish infections not only in rodents but also among livestock and domestic animals and act as carriers for many years or even for a lifetime (9).

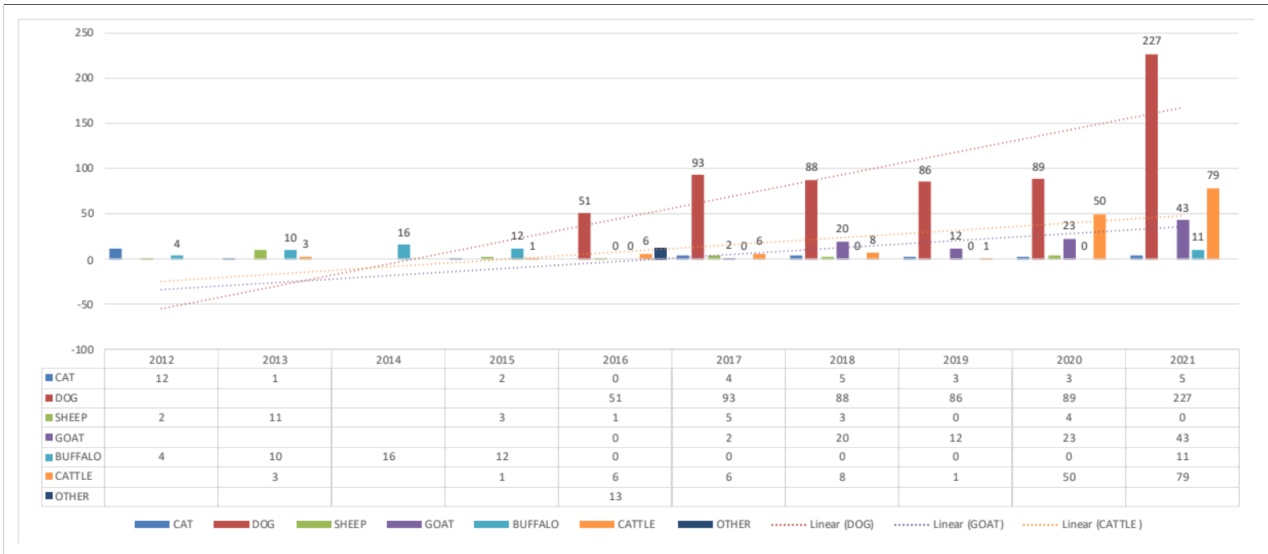


Figure 3. Notified cases of leptospirosis among animal species in Kerala from 2012-2021

3.4 Rabies

Between 2012 and 2021, a total of 3,375 rabies cases were notified among animal species in Kerala. The most common species being dogs 1554 (46%), followed by cattle 1211 (35.8%). The highest num-

ber of cases were notified in the year 2020, 565 (16.7%) and 2019, 498 (14.7%). The trend of rabies among the dogs shows an increasing

one while among the cattle species shows a stable trend (Fig.4). This finding is of considerable public health importance, as dogs are responsible for approximately 96% of human rabies deaths (10) and are the animal species in closest and most frequent contact with humans.

Because the vast majority of human rabies cases stem from dog bites, robust surveillance and control of canine rabies are essential to meet the 'Zero by 30' target of eliminating dog-mediated human rabies deaths by 2030 (11).

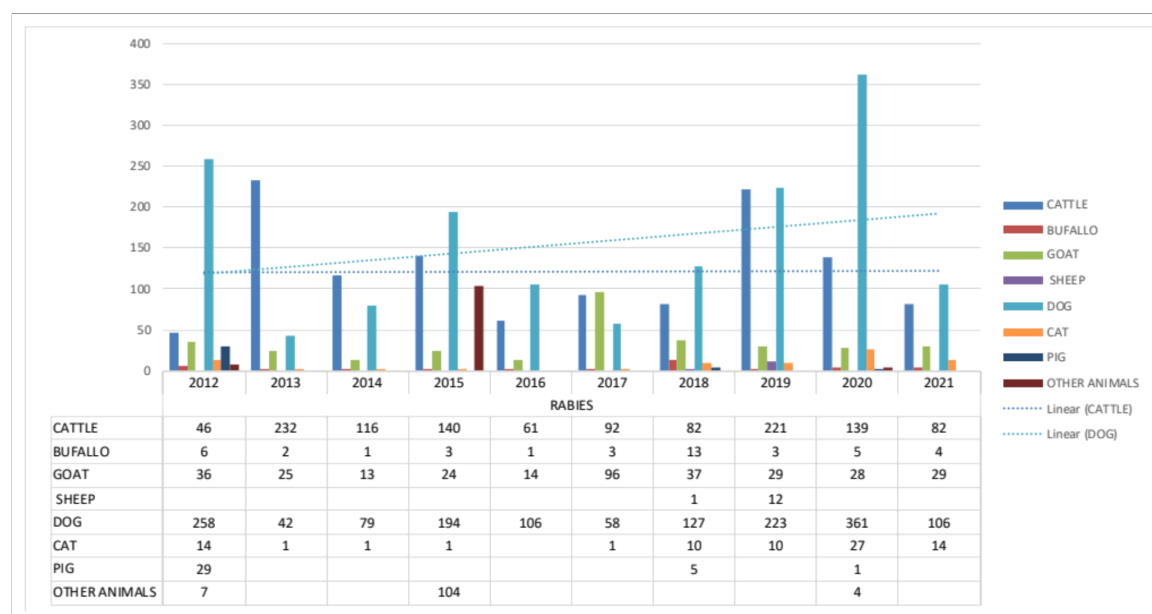


Figure 4. Notified cases of rabies among animal species in Kerala from 2012-2021.

3.5 Newcastle disease (Ranikhet disease)

A total of 297,402 cases of Newcastle disease were notified in Kerala among the animal species from 2012-2021. The majority of the cases were among fowl 287,411 (96.6%) followed by other species of birds 6391 (2.1%) and ducks 3600 (1.2%). Though Newcastle disease is classified a highly contagious avian zoonotic disease it can infect humans and can cause flue like illness and conjunctivitis when the person has been exposed to large quantities of the virus. The highly path-

ogenic form of the virus is reportable to the WOAHA as it is a listed in the Terrestrial Animal Health Code (12). There is an increasing trend of Newcastle disease among the fowl species over the years studied (Fig.5), which is also of relevance to the poultry industry in the state. Another important phenomenon is the potential for Newcastle virus and avian influenza virus coinfection as both are RNA viruses and can complicate the transmission dynamics and pathogenicity in avian species and affect the ecological niche (13). This warrants further surveillance, research and exploration.

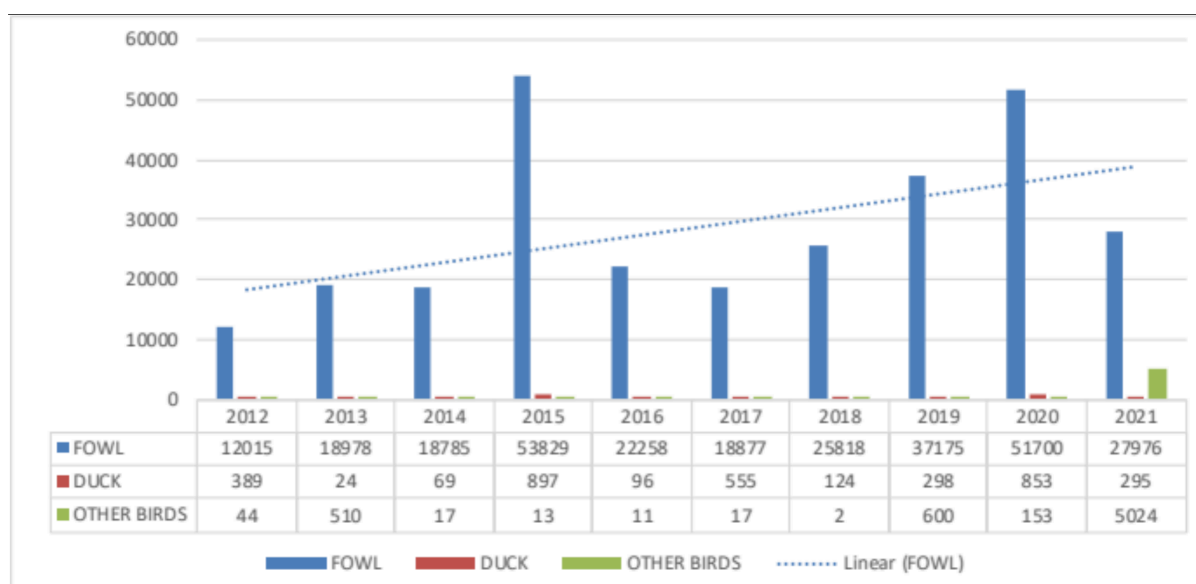


Figure 5. Notified cases of Newcastle disease among animal species in Kerala from 2012 to 2021

3.6 Salmonellosis

A total of 16170 cases of salmonellosis among animal species were reported in Kerala from 2012-2021. The majority of the cases were in the year 2020, 3381 cases (20.9%) followed by 2019, 2914 cases (18%). The most common species affected were fowl 14520 (89.8%). The trend of salmonellosis shows an increasing one over the years (Fig.6).

The incidence of salmonellosis among the animal species is quite significant in that it can cause foodborne illnesses in humans as they are the main vehicle for transmission. Consumption of contaminated food of animal origin, like eggs, meat, poultry and milk, green vegetables contaminated by manure are common sources of infection. There is a lack of information on the incidence of human salmonellosis in Kerala and its attribution to the incidence among fowl or animal species. Therefore, salmonella outbreaks in humans as well as ani-

imals have to be investigated with a One Health perspective. The National Centre for Disease Control (NCDC) reports that “*Salmonella* is the most common cause of foodborne illnesses (14). This is of great

significance to the food industry and food handlers. Managing and mitigating human salmonellosis necessitates a collaborative action from both industry stakeholders, policymakers & administrators.

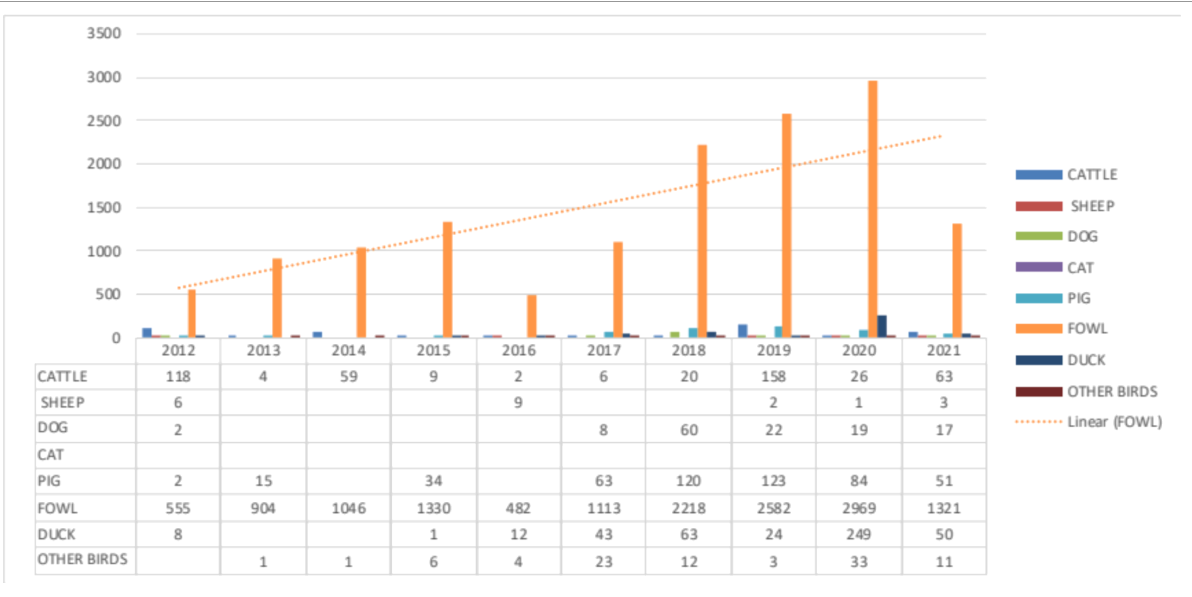


Figure 6. Notified cases of salmonellosis among animal species in Kerala from 2012 to 2021

3.7 Bovine tuberculosis

Between 2012 and 2021, a cumulative total of 249 animal tuberculosis cases were notified across various species in Kerala. The majority of the cases were reported in the year 2020, 83 cases (33.3%) followed by the year 2021, 36 cases (14.5%). The most common species affected were cattle 119 (47.8%) followed by goat 96 (38.6%) and both species have an increasing trend (Fig.7). Bovine tuberculosis is mainly attributed to *Mycobacterium bovis* species, a bacteria belonging to the group named *Mycobacterium tuberculosis* complex which

also includes *Mycobacterium tuberculosis*, the primary causative agent of tuberculosis among humans. The main route of transmission of *M. bovis* to people is indirect and is mostly transmitted through the consumption of contaminated milk and other dairy products that have not been heat-treated (15). A metanalysis done by Srinivasan *et al* has concluded that the pooled estimate of the prevalence of bovine tuberculosis among cattle in India as 7.3% (95% CI: 5.6, 9.5) (16). The WHO also reports that Zoonotic Tuberculosis (zTB) / Bovine Tuberculosis (bTB) are endemic (17) in India, and it will be of significance as we are in the phase of TB elimination in India and that the true burden of zTB is still underestimated(18).

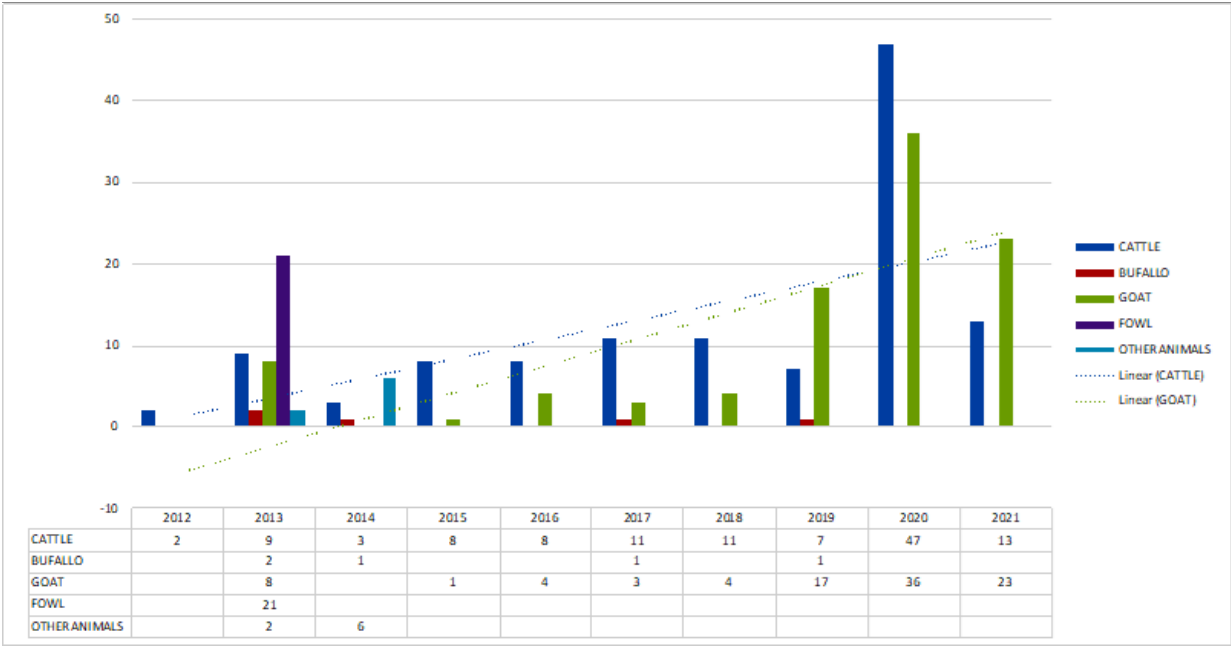


Figure 7. Notified cases of tuberculosis among animal species in Kerala from 2012 to 2021

4. Conclusion

Zoonotic diseases among animals represent a massive public health challenge. Diseases like brucellosis, leptospirosis, rabies, Newcastle disease, salmonellosis and bovine tuberculosis are endemic on one or

the other animal species in Kerala. leptospirosis exhibits a widespread distribution across both domestic and companion animal reservoirs living in close proximity to humans. With regard to rabies, the trend is increasing in dogs, and they represent the animal species in closest and most frequent contact with humans and any upward trend in ca

nine rabies cases directly translates to an elevated risk of human exposure and fatalities. Newcastle disease is highly endemic among the fowl species and needs continuous monitoring and surveillance. Salmonellosis among fowl species is on a steep upward trend and needs to be controlled as it is the most common cause of food borne illnesses. Bovine Tuberculosis is also on an upward trend especially among cattle and goats, the role of these on human tuberculosis needs to be explored. Incidence of Anthrax have to be monitored closely to prevent large outbreaks. Tackling zoonotic threats demands a unified front. Effective containment of zoonotic disease relies on understanding the epidemiology in a One Health perspective, with integrated surveillance serving as the definitive starting point. This can help the health systems transition from a reactive response to a proactive containment of outbreaks.

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Conflict

of Interest: We declare no conflicts of interest.

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