INTRODUCTION

Leptospirosis caused by pathogenic spirochetes belonging to the family Leptospiraceae, genus Leptospira is an important cause of abortion, stillbirths, infertility, poor milk production and death amongst livestock. It may have a significant economic impact on the livestock industry. Its epidemiology may be complex and transmission of infection involves recirculation of the pathogens among reservoirs which includes domestic and wild animals.

It is increasingly recognized as an emerging zoonotic infection worldwide, partly brought about by factors such as climate change and demographic shifts, and believed to be grossly underestimated as public health and veterinary concern. Farmers, dairy industry workers, veterinarians, sewer workers, pet keepers, rodent catchers, fishermen, miners, military personnel, international travellers and those persons participating in aquatic leisure activities are more prone to acquire the disease.

Humans are incidental hosts acquiring a systemic infection upon direct or indirect exposure to the urine, blood or tissue of an infected animal. Leptospirosis seems to have been less well studied in wildlife - in epidemiological as well as many other aspects of the disease. This article will deal with the findings of a few recently published articles on leptospirosis with emphasis on wildlife.

CLASSIFICATION OF THE ORGANISM

Conventional classification of Leptospira is based on serological criteria dividing them into two species - the pathogenic Leptospira interrogans sensu lato and the saprophytic Leptospira biflexa sensu lato. More than 60 serovars have been described for Leptospira biflexa. Currently more than 250 serovars separated into 25 serogroups are recorded Leptospira interrogans.

The serological classification system is also comple-
global context, the disease is widespread and considered as emerging or re-emerging, according to the geographical area and time, or as neglected.

Lindsey et al. (2009) reported wildlife ranching to be increasingly recognised as a productive form of land use on marginal lands where alternatives such as agriculture are far less viable. Other developments were legislative changes during the 1960–70s which granted landowners the right to utilize wildlife on their land. Due to a combination of a rising demand for tourism and safari hunting, recurrent droughts, overstocking with livestock blamed for range degradation and reduced productivity which coincided with declining state subsidies for livestock production it has resulted in a huge shift from livestock farming to wildlife ranching in many parts the South African region.

Citing Zimbabwe, South Africa and Namibia as examples: In Zimbabwe 1,000 wildlife ranches were developed, covering an area of 27,000 km² (prior to the land seizures in 2000), in South Africa 9,000 wildlife ranches covers 205,000 km². In addition to 15,000 mixed livestock and wildlife ranches whilst in Namibia, wildlife ranches and communal conservancies encompass 288,000 km².

In many other parts of Africa wildlife numbers may have declined and habitat may have shrunk but the bush meat trade remains of great economic significance and especially in rural and less developed economies. Such communities may rely heavily on bush meat as a vital nutritional, economic and cultural component of their livelihoods. A large number of scientific papers have been published in which many aspects of the bush meat trade have been investigated. More recent publications also put more emphasis on the importance of zoonosis and the One Health Approach. Some of these studies claim that by estimate 282 grams of bush meat are consumed per person per day in the Congo Basin.

It is stated that three million tons of bush meat is harvested in Central Africa annually whilst market surveys estimating that over 900,000 kilograms of bush meat are sold annually in Nigeria alone. In many instances profit margins are large enough to create sufficient incentive for the bush meat trade to allow bush meat to reach national and international markets. The bush meat trade is valued at 150 million USD in the Ivory Coast as example and it is estimated that five tons of bush meat are smuggled from Africa to Europe per week. Worldwide, wildlife is second only to narcotics among black market trades.

Contact with wildlife through the bush meat trade may put people at risk of infection with zoonotic pathogens such as simian immunodeficiency virus, human T-cell lymphotrophic virus, simian foamy virus, monkeypox virus, Ebola and Marburg filoviruses, anthrax, herpes viruses, hepatitis viruses, paramyxoviruses and various parasites. Hunters come into contact with wildlife significantly more than non-hunters. Participants in surveys reported hunting rodents (95%), ungulates (93%), carnivores (93%), primates (87%), and bats (42%), among other prey.

The current knowledge base and focus has been very biased towards the developed agricultural economies and the lack of information on the disease situation in the developing economies, and wildlife, presents a major challenge as humans and animals frequently live in close association.

AFRICAN WILDLIFE

In comparison to humans and domestic animals it would seem that leptospirosis in wildlife remains less studied and wildlife is less frequently considered in leptospiral surveillance programmes. As little as 14.4% (13/90) of animal surveys for leptospirosis since 1970 have included wildlife in sub-Saharan Africa.
SOUTHERN AFRICA
Following on an extensive literature search de Vries et al (2014) found that in Zimbabwe rhinoceroses, buffalo, eland, wildebeest and zebras were species with seropositive titres. The numbers of rhino testing positive varied from 63.0% to 4.9% in limited and relatively small numbers of animals screened (group sizes of 60 and 102 respectively).

In South Africa it was found in 26.4% rhinoceroses (182 animals) originating from four national parks, 7 out of 406 buffaloes from Kruger National Park and 8.0% Vervet monkeys (50 animals) all screened seropositive. Fifty seven animals from eleven different species were screened in Northern Kwa-Zulu Natal and of these six animals tested seropositive as listed below (with the positive serovar in brackets): 1 Nyala (Tassarovi), 2 black rhino (Mini, Hardjo,Copenhagani, Pomona and Tarrasovi), 1 reedbuck (Mini), 1 bushpig (mini), and 1 blue wildebeest (Mini).

Jobbins et al (2015) reported on the first large-scale assessment of renal carrier states of Leptospira sp among African wildlife in the Chobe national park in Botswana. Employing polymerase chain reaction (PCR) screens 69 different species were examined and 17 species (24.6%) tested positive for renal carriage of Leptospira sp. Findings revealed positive results in 31.4% (11/35) of mammals, 27.8% (5/18) of bird and 6.3% (1/16) of reptile species. The findings of their study revealed that all the positive sequences featured a region specific for pathogenic Leptospira. These were identical to Leptospira interrogans from banded mongoose Genbank :JX254899, and the pathogenic L. interrogans serovars Lai (Genbank:NR-076185) and Copenhageni (Genbank: NR-076199).

Renal carriage states in warthog, white-tailed mongoose, Angolan free-tailed bat, African savannah hare, tree squirrel, aardvark, Cape turtle dove, southern ground hornbill, arrow-marked babbler, glossy ibis, barn owl and herald snake are all reported by the authors. A high prevalence of Leptospira sp DNA was also observed in banded mongoose Genbank JX254899, and the pathogenic L. interrogans serovars Lai (Genbank:NR-076185) and Copenhageni (Genbank: NR-076199).

CENTRAL AFRICA
Duikers from five different species were serologically screened in the Ituri forest (in the then Zaire) and 5/61 had a single positive titre whilst 5/61 had positive titres against more than one serovar. The most common serovar was Leptospira interrogans hardjo. The seroprevalence of Leptospira hardjo in African buffalos (and cattle) was determined by Atherstone et al (2014) in the southwestern Uganda. Positive results were found in both cattle and African buffalo from two locations and the seroprevalence was 42.39% in African buffalo and 29.35% in cattle.

WILDLIFE IN THE REST OF THE WORLD
A number of studies were published from different regions of the globe. Petrakovsky et al (2014) reviewed the status of leptospirosis in Latin America and the Caribbean countries. They reported the following wildlife species to show serological evidence of infection by Leptospira sp.

In Argentina arboreal squirrels, south American gray foxes, wild and domestic carnivore (Leopardus geoffroyi) and pampas deer. In Brazil non-human primates (Cebus paella, Alouatta caraya, Nasua nasua), gray foxes (Cerdocyon thous), rodents (Dasyprocta sp.), capybaras, anteaters, armadillos, wild canids (Cerdocyon thous, Cynocephalus brachyurus, Speothos venaticus, Pseudalopex vetulus), raccoons, white-lipped peccaries, collared anteaters, ocelots, marsupials, (Didelphis albiventris) and pumas.

In Colombia Rattus rattus, Mus musculus, neotropical primates (Ateles fusciceps, Ateles geoffroyi, Cebus albifrons, Cebus paella, Cebus capucinos and Saginus leucopus), Puma, ocelot. (Panthera onca, Leopardus tigrinus). In Peru captive collared paca- caries RT (Tayassu tajacu), capybaras, Rattus rattus, Proechymis, marsupials.

The presence of the Leptospira serovars Pomona, Autumnalis, Bratislava, and Copenhageni was demonstrated among the captive vicuña populations in Peru in a survey by Risco-Castillo et al (2104). Their serological survey results revealed 1.9 % (4/207) of vicuñas, 18.6% (106/571) of alpacas, and 23.3 % (10/43) of llamas to be positive to one or more Leptospira serovars. Serovars Pomona and Autumnalis were the most seroprevalent among the alpaca, lama, and captive vicuñas and no animals were sero-positive to Hardjo (more adapted to true ruminants).

Infected livestock, rodents, guinea pigs, wild rodents, such as the northern viscacha, collariago or Andean pygmy mouse, as well as opossums, weasels, or hog-nosed skunks, wild mice of the Akodon genus, and the Andean fox could all be implicated in Leptospira transmission to vicuñas. In Ontario,
Canada Shearer et al (2014) obtained (from road-kill and hunter/trapper operations) a total of 460 kidney samples from wildlife (beavers, coyotes, deer, foxes, opossums, otters, raccoons, skunks) between January 2010 and November 2012. Samples were tested by means of immunohistochemistry and polymerase chain reaction (PCR) with positivity ranging from 0% to 42%, with the highest rates in skunks and raccoons. Beavers, foxes and opossums also tested positive whilst otters, deer and coyotes screened negative. Leptospira spp were present in kidneys of wildlife particularly in areas of high human density, and areas in which livestock is abundant.

Andreoli et al (2014) in an investigation in the central Italian Alps examined 441 serological and 198 renal samples from red deer, roe deer and chamois. Positive serological results were found only in 15 red deer and 19 positive serologic reactions were recorded with the most frequent serovars being Bratislava and Grippotyphosa, followed by Pomona, Hardjo and Copenhageni.

In Mauritius Rusa deer is reared as a main source of red meat for the local population. Jori et al (2014) found significant associations between seroprevalence to some of the leptospiral serogroups detected (Tarassovi, Pomona, Sejroe and Mini) and the age of the animals, animal density or location of the estates (being more prevalent in hotter and more humid areas).

LEPTOSPIROSIS IN NON-HUMAN PRIMATES
Ellis (2015) reports the general lack of published data about leptospirosis in non-human primates. High seroprevalences have been found in a various species in captivity such as new world monkeys, macaques and up to 42 % of captured vervet monkeys. Investigations revealed Icterohaemorrhagiae, Pomona and Grippotyphosa strains as the predominant in captive primates. Ballum was the predominant serovar detected in free-living vervet monkeys following capture.

Severe and sometimes fatal clinical disease has been observed in capuchins, squirrel monkeys, marmosets, tamarins and macaques with the disease spectrum resembling that seen in humans. Severe icteric, anicteric, and pulmonary forms were described and meningocencephalitis and abortion has also been reported.

LEPTOSPIROSIS IN DOMESTIC AND WILD FELIDS
Ellis (2015) reports that cats are regarded as being very resistant to leptospirosis and although significant seroprevalences have been reported in various cat populations very few reports of clinical disease are, however, present. Attempts at experimental infection have mostly failed. Evidence of renal carriage in cat populations in Reunion Island and Taiwan have recently been reported to be a 29 % and 67 % PCR positive rates respectively.

A similar situation in wild felidae is presumed, with only the Iberian lynx being associated with significant clinical disease. Serological surveys carried out in Brazil revealed exposure of captive jaguars to the serovars Castlelonis, Hardjo, and Copenhageni whilst Pomona was the most prevalent serovar found in free-living sampled jaguars. A more recent study by Onuma et al (2015) reported high antibody titres to serovar Canicola in two jaguars. The main natural reservoir is the dog, suggesting an occasional contact between jaguars and domestic dogs.

LEPTOSPIROSIS IN CAMELIDS
Ellis (2015) quoting several studies and authors mentioning that high seroprevalences have been reported in alpacas, vicunas and llamas and lower seroprevalences in guanacos in South American countries. Seroprevalence rates have been low and ranging from 0–12 % in dromedaries from North Africa and the Arabian peninsula. A seroprevalence of 50% has been reported in Rajasthan.

Leptospirosis in feral pigs and wild boar Feral swine (Sus scrofa) have markedly increased their range and population sizes by continually expanding into urban areas in many areas of the world in the last 2-3 decades. As consequence their ranges nowadays may overlap to a significant extent with domestic swine and human activities. Transmission of Leptospira sp is becoming of increasing concern.

Sera from 2055 feral swine in the United States were examined by Pedersen et al (2014) for antibody presence to six serovars of Leptospira and 13% of all samples tested positive for at least one serovar, suggesting that Leptospira infection is common in feral swine.

Vale-gonçalves et al (2014) quotes several authors whom have reported seropositivity to different serovars of Leptospira sp in wild boar populations worldwide. Positive titres to tarassovi have been reported to be frequent and the most reactive serovar observed in wild boar from Slovenia. Serovar Pomona is the most frequently reported in wild boar populations in Spain and Germany and the second most common in Croatia.

In a study by Vale-gonçalves et al (2014) they obtained serum samples during the 2011 – 2013 hunting seasons in northern Portugal and screened it against 17 different pathogenic serovars of Leptospira sp. Seropositivity was detected against nine serovars in 66 (65.4%) of these samples. They found the highest seroreactivity rates against serovars.
Tarassovi and Altodouro (23.8% and 16.8%, respectively), followed by Autumnalis (7.9%) and Bratislava (6.9%). Age and the district of origin were identified as risk factors in contrast to gender.

During the hunting season 2012-2014, 3621 blood samples from wild boars were collected in Poland originated from different geographical areas across Poland. Serum samples were tested for the presence of specific antibodies to the Leptospira serovars: Icterohaemorrhagiae, Grippotyphosa, Sejroe, Tarassovi, Pomona, Canicola, Bratislava, Autumnalis, Hardjo and Ballum. Antibody titers to all Leptospira serovars except serovar Ballum were found in 377 serum samples (10.4%).

LEPTOSPIROSIS IN CERVIDAE
In his review Ellis (2015) reports that the most detailed information is available for farmed red deer in New Zealand, where serovar Hardjo is most common, Pomona less common and Copenhageni uncommon. Hardjo has also been recovered from rusa deer while mixed Hardjo and Copenhageni infections have been observed in some animals. Experimental infection of pronghorns with Hardjo has been described. Pomona strains have been the most common isolates from deer and reported in red deer, white-tailed deer and rusa deer.

CLINICAL DISEASE AND SIGNS
Ellis (2015) refers to reports of clinical disease in a diverse range of zoo animals, black rhinosceros, a giant anteater, a polar bear, black tailed deer and a wild dog. Leptospirosis is recognized as one of the most common causes of stranding and mortality in the Californian sea lion. Disease is characterized by liver and kidney infection resulting in acute renal failure and death. Other pinnipeds also known to be affected includes northern fur seals, northern elephant seals and harbor seals.

Ellis (2015) reports that although limited information is available in buffalo the situation in domestic buffalo is very closely resembling that seen in cattle. High seroprevalences have been found in virtually all investigations and it is quoted that acute disease has been associated with jaundice, fatal haemorrhagic syndrome and agalactia with abortion as a sequel in this species.

Information on clinical leptospirosis in camels is lacking but abortion is a feature and leptospires were demonstrated in 8/49 aborted foetuses (7 by PCR and culture and 1 by PCR only).

In farmed red deer in New Zealand serovar Hardjo is subclinical, with losses between birth and weaning and poorer live weight gain being the only possible clinical effects identified. Pomona is more likely to cause clinical disease, and Copenhageni infection has been associated with clinical disease. Infection has been identified in a foetus from a herd with a Hardjo titer. Pomona infection has been implicated in acute hemolytic disease of red deer, mule deer and white-tailed deer.

CONCLUSION
The One Health operational concept has been promoted and its advocates has defined it as a collaborative efforts of multiple disciplines working locally, nationally and globally to achieve optimal health of people, animals and the environment. It has impetus in the history of Ebola hemorrhagic fever and avian influenza epidemics - both diseases in which whose transmission mechanisms exist at the animal-human-ecosystem interface - both examples of diseases which has a negative impact on human and animal health and related to economic issues.

Globally leptospirosis is widespread and considered as emerging or re-emerging, or neglected in different geographical areas, and in different time spans, in both socio-economic and political context. By estimation there may be well over 1,700,000 severe cases of leptospirosis worldwide. The incidence of human disease in the Americas, as example, is high, estimated at 12.5 cases per 100,000 inhabitants, compared with a global incidence of 5.1 cases per 100,000 inhabitants. The question raised is if there will be a renewed global interest in leptospirosis and in particular in the role that wildlife may play.