Rabies in kudu and eland #3:
How vaccination leads to immunity

In the previous articles in this series we spoke about rabies and what implications this disease can have for game farmers (see the documentation section on our website). We also explained important concepts regarding disease transmission, such as herd immunity and social distancing. The main message we want to get across is that, esp. in high risk areas, it is worth it to vaccinate your game against common and important diseases (not just kudus and eland against rabies). In this article we explain how immunity works and how animals and humans become immune to a disease after a vaccination and/or natural exposure.

The immune system

The immune system is made up of a specialized network of cells, tissues and organs that work together and are constantly on the lookout for invaders such as bacteria and viruses. Its function is to prevent or limit infection. The immune system can differentiate between normal healthy, and unhealthy cells, by detecting proteins that are found on the surface of all cells. Each cell type within the immune system plays a unique role. Some recognise disease-causing organisms and then trigger a chain reaction, leading to the formation of antibodies and the eventual destruction of the invader by inflammatory cells. Some specialised "memory cells" survive for decades and store the "programming" to quickly recognise and stimulate specific antibody production if a patient is re-exposed to the same disease.

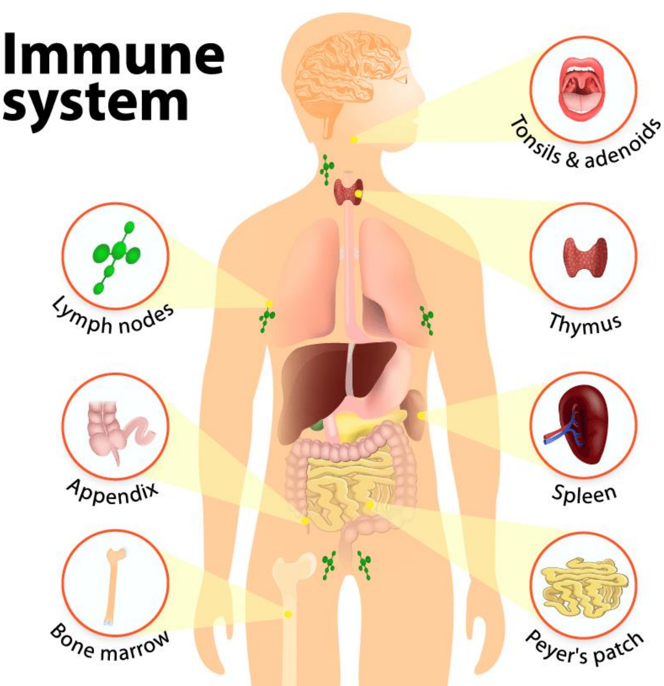

Figure 1 Human immune system © RevereHealth

Parts of the immune system

The immune system is very complex (Figure 1) and consists of specialised cells located in different organs.:

- White blood cells: These cells, mostly formed in the bone marrow, are the key part of the immune system. They basically form an army against harmful bacteria and viruses, they search for and attack invaders. Some examples of white blood cells:
  - Phagocytes; they 'eat' the invader
  - Lymphocytes produce antibodies against infections, "memorise" the code of infections a patient has previously been exposed to (disease or vaccination) and also have specialised killer cells that help destroy pathogens and abnormal cells in the body.
  - Neutrophil; they fight bacteria
- Lymph nodes: these small nodes are like a road block; they filter and take out invaders so that they cannot spread to other parts of the body. Lymph nodes also contain lymphocytes that analyse the invader. They then activate a chain reaction to fight off the invader. When a lymph node is

Dr. Ulf Tubbesing
P.O. Box 50533 Bachbrecht, Windhoek
☎ +264 (0) 81 128 0350 ulft@africaonline.com.na
www.wildlifevetsnamibia.com

swollen, it often means that the body is fighting against an infection. The tonsils, adenoids and payers' patches in the intestine play a similar role.

- Thymus: this organ helps to mature certain white blood cells. These cells learn to recognize and remembers invaders.
- Spleen: Is a store of both red and white blood cells. It plays an important role in defending the body against invaders, and it filters and removes old and damaged red blood cells. When doing a Post-Mortem, we always first check the spleen. When big, it usually suggests a systemic disease with anthrax high on the list.
- Bone marrow: in the spongy centre of the bones stem cells develop into red blood cells, plasma and a variety of white blood cells.
- Skin, mucous membranes: Being a physical barrier, this is the first line of defence in preventing invaders from accessing the body.
- Stomach and intestines: stomach acid kills many bacteria, while normal, beneficial bacteria living in the intestines kill harmful bacteria.

When a disease organism enters the body, the immune system picks up specific organism surface characteristics, called antigen (Ag). This triggers the immune reaction, with the B lymphocytes (a type of white blood cell) triggering the production of specific antibodies (Ab) (also called immunoglobulins) against that antigen (Figure 2). These antibodies attach to the antigen to form a so-called antibody-Antigen complex. This then activates T lymphocytes as well as other white blood cells (phagocytes) who destroy the invaders.

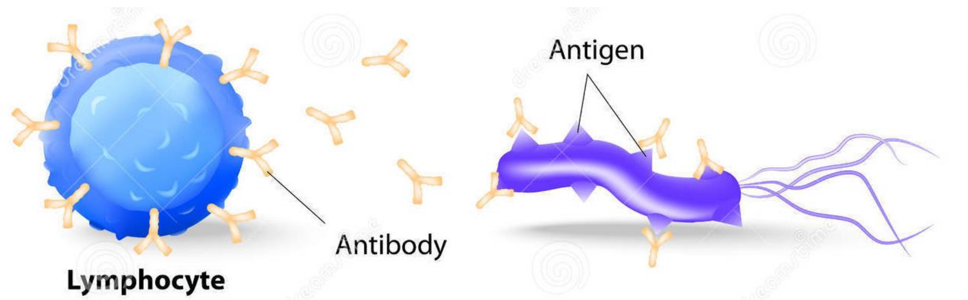

Figure 2 The lymphocytes (a type of white blood cell) create specific antibodies. These antibodies then attack the invader (antigen). © [Dreamstime]

All antibodies produced are very antigen specific to the bacteria or virus detected. Once an Ab-Ag reaction takes place (lock and key effect), and trigger a specific immune response (Figure 3). These specific antibodies remain in the body, even after the invader has been destroyed. When the same invader enters the body again, the immune system will remember it, and will quickly destroy the invader before it makes the body sick. This protection is called immunity.

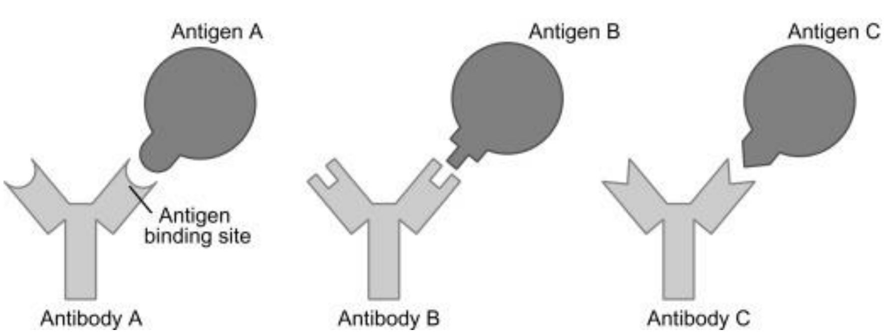

Figure 3 Antibodies are special proteins that lock onto specific antigens. The shape of antibodies varies, and matches the shape of the antigen perfectly. © *Thomas M. Chused*

Dr. Ulf Tubbesing
P.O. Box 50533 Bachbrecht, Windhoek
☎ +264 (0) 81 128 0350 ulft@africaonline.com.na
www.wildlifevetsnamibia.com

There are three types of immunity (Figure 4):

- Passive immunity - is 'borrowed' from another source, and usually last a short time. The best example is temporary protection that an infant derives from colostrum milk from their mother.
- Innate immunity - an immediately available, non-specific protection against disease which is present from birth.
- Adaptive immunity - this specific immunity against specific disease develops throughout life, as the body gets exposed to diseases, or when its vaccinated. The body builds up a 'library' of antibodies.

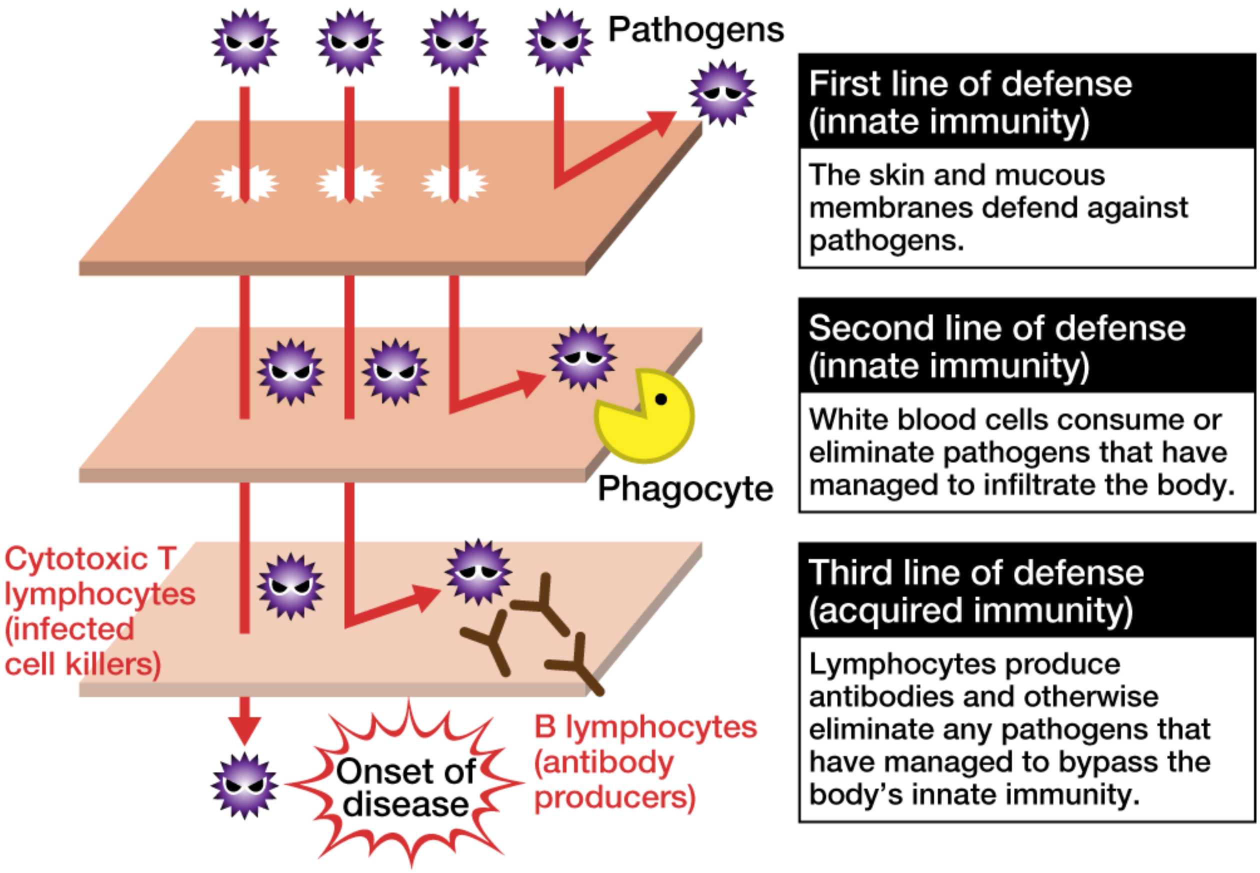

Figure 4 The three types of immunity © M. Masayuki

Vaccination

Vaccines provides a patient the opportunity to become immune without having to get sick first. Generally, vaccines are made of killed or weakened versions of the disease-causing organism (antigen). When a vaccine is injected, the body basically reacts in the same way as if it was exposed to the real disease.

The immune system sees the antigen as an invader → it responds by making antibodies → it remembers the antigen and how to destroy it (Figure 5).

Dr. Ulf Tubbesing
P.O. Box 50533 Bachbrecht, Windhoek
+264 (0) 81 128 0350 ulft@africaonline.com.na
www.wildlifevetsnamibia.com

Next time, when the body is exposed to the specific antigen, the immune system will with the aid of memory cells be able to quickly identify and destroy the disease-causing organism before it can cause disease. This is how immunity is acquired from a vaccine.

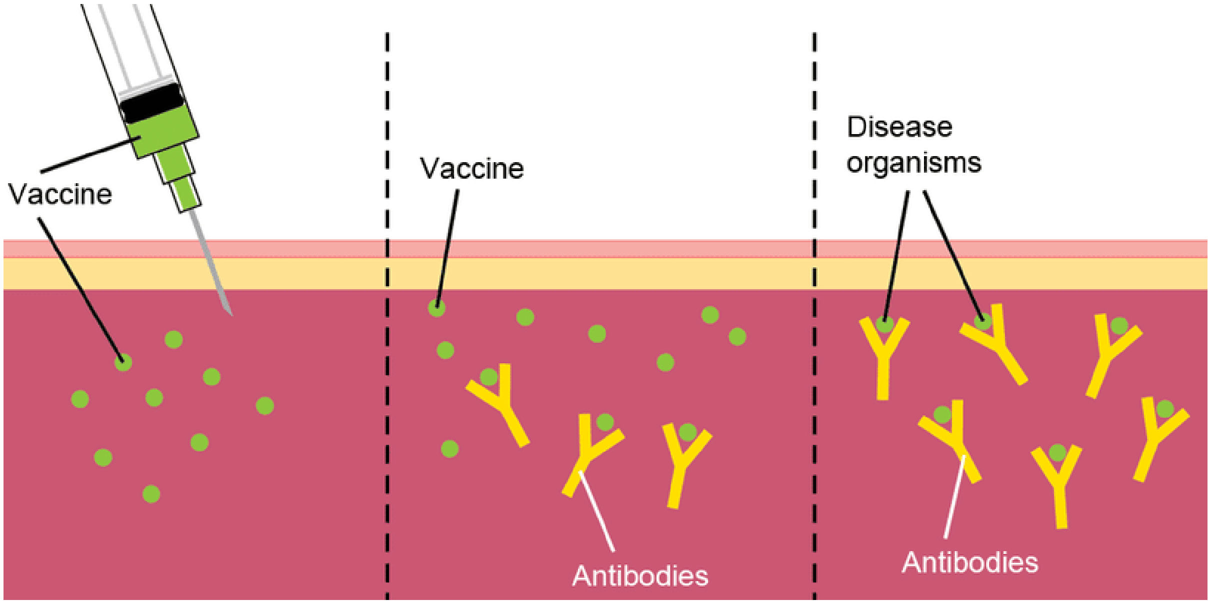

Figure 5 Schematic drawing on how a vaccine works; a weakened or killed form of a disease is injected. The body creates antibodies to fight against the disease. Whenever the disease comes back, the antibodies return and destroy the disease © [Frank Adusei-Mensah]

Vaccination has proven to be a highly effective tool to drop the numbers of many diseases both in human and veterinary medicine (Figure 6). Some diseases, such as smallpox, have completely been eradicated. Most other diseases still exist, but due to vaccinations they are now considered rare. Regular vaccination is needed to keep a population healthy. Infectious diseases are easily passed on from animal to animal (or person to person), infecting entire populations. If a high percentage of a population is vaccinated disease spread to unvaccinated animals is hampered through herd immunity (this concept is explained into detail in the 2nd article in this rabies-series).

A decrease in vaccination (e.g. the new "anti-vaxxer movement") results in new outbreaks of once eliminated diseases e.g. the measles outbreaks in the USA in 2019.

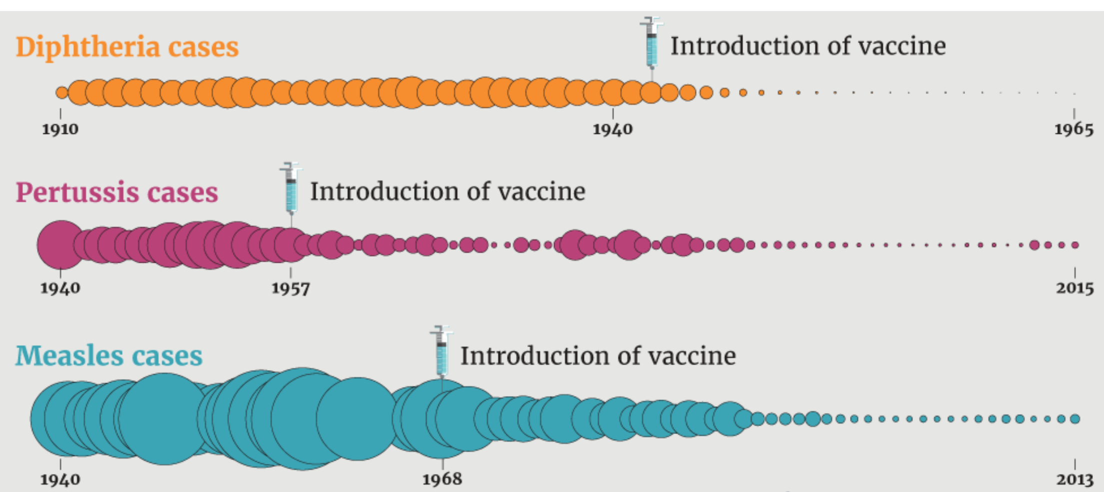

Figure 6 Some life-threatening diseases, such as diphtheria, pertussis (whooping cough or kinkhoes in Afrikaans) and measles used to be very common amongst young children in the UK. After scientists developed a vaccine for these diseases, a massive drop in the number of cases of these diseases have been observed. © *British Society of Immunology*

Dr. Ulf Tubbesing
P.O. Box 50533 Bachbrecht, Windhoek
+264 (0) 81 128 0350 ulft@africaonline.com.na
www.wildlifevetsnamibia.com

Booster vaccinations

As you probably know, following the first vaccination, the doctor or vet wants you, your child or your pet to return for a booster vaccination at a later stage. Why?

When a vaccine is given (or a disease is acquired), the body starts an immune response. The initial rate and magnitude of antibody production is at a modest pace, this is a primary immune response. However, following a booster vaccination or, a re-exposure to the disease, there is a near immediate and massive response by the B and T lymphocytes. Antibodies circulate in massive numbers and rapidly eliminate the disease - this is the so-called secondary immune response (Figure 7).

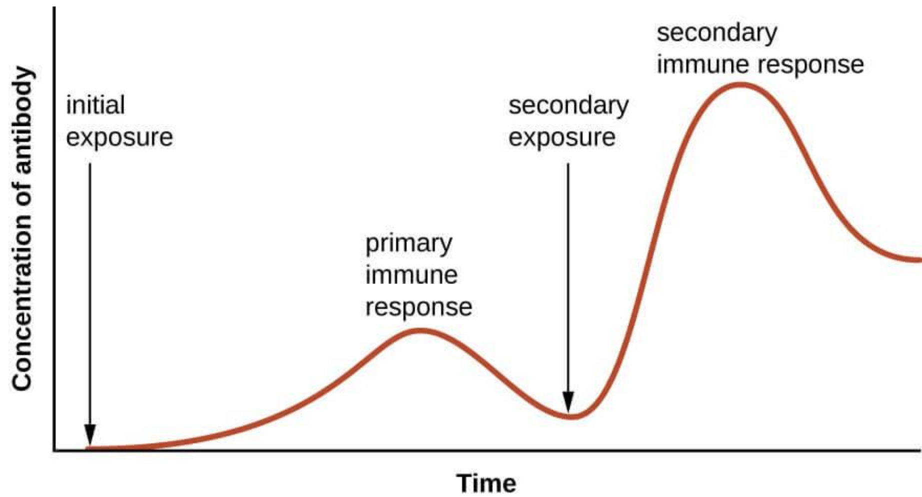

Figure 7 When an antigen enters the body, an immune reaction will occur after a specific time. If the same antigen enters the body again after a few months or even years, a secondary immune response will be shaped, and the antibodies' response will be faster, and longer-lasting. © Immune System Health

When a patient is not re-exposed to a disease for a long time (months to years) the body gradually loses the advantage of the "memory cells" with the result that the patient once again gradually becomes susceptible to that disease.

This explains why re-vaccination (or booster) is so important. The need for and frequency of booster vaccinations needed depends largely on the disease involved and the type of vaccine used. For some diseases and vaccines a single booster is needed for life-long protection, whereas others need an annual booster (e.g. anthrax and botulism).

Table 1 Some differences between primary and secondary immune response

	Primary immune response	Secondary immune response
Definition	Occurs as a result of a primary contact with an antigen	Occurs as a result of a second or subsequent expose of the same antigen
Response time	Slow, appear late, are short lived	Quickly, powerful and long-lasting
Antibody producing cells	Naïve B lymphocytes	Memory B lymphocytes
Antibody levels	Antibody levels peak on in 7 to 10 days, then begin to drop	Peak in 3 to 5 days, 100-1000 times higher antibody levels
Lag period (time needed to activate the B lymphocytes)	4 to 7 days	Absent or short (1 to 3 days) due to presence of memory cells

Rabies vaccine in kudu and eland

The first documented case of rabies in kudu in Namibia was in 1975, near Windhoek. A major outbreak followed from 1977 to the late ‘80s, whereby an estimated 30,000 to 50,000 kudus died of the disease. In 2002 another outbreak was reported, by 2003, an estimated 2,500 kudus had died ([Scott *et al*., 2012]). Why did so many animals die? These massive disease outbreaks usually follow an increase in the kudu population following a good rains, better protection and breeding for trophy hunting/tourism and a reduction in the number of predators on farms. A large unvaccinated population, is much more likely to get infected, and spread the disease than a vaccinated or small population.

Figure 8 Dart vaccinating kudus against rabies from the helicopter. So far this is the most cost-efficient way of protecting entire populations. © Wildlife Vets Namibia

Over the past few years we have noted that rabies outbreaks in kudu and eland are a common occurrence. As a result, we have been advocating regular vaccinating against rabies. Over the years we have done so on a number of game farms, both during and following an outbreak. Those farms where we prophylactically vaccinate annually or biannually now support a thriving kudu population. On farms with an ongoing rabies outbreak the farmers reported the outbreak stopped within 10-14 days of vaccination with only rare mortalities noted after this.

Considering the high demand for and value hunters attach to a kudu trophy and the resultant high live kudu prices of +/- 8000N$ for kudu cows, and 18.000N$ for a 47” kudu bull (Super Game Dealers auction 2020), it is well worth your money to protect them against rabies.

When we dart vaccinate kudus and eland, we want to stimulate an immunological memory – the immune system must recognize and attack the rabies virus. As explained, the vaccine triggers the production of antibodies, and memory cells that stay in the body. Because the antibodies don't last forever, an annual or biannual booster vaccination is essential. This has been shown in research done on cattle, whereby cattle were vaccinated against rabies. One month after the first vaccination, 80% of cows had rabies antibodies. After 1 year, this decreased to only 42%. In cattle that received a booster vaccination a year after the primary vaccination, it showed that 96% of the cows had rabies antibodies.

Let’s put this into an example for kudus. In this example we ignore the fact that anti-rabies antibody levels decline with time and we mostly consider the important concept of herd immunity:

> *2018: We vaccinate 70% of a kudu population with 100 individuals – thus 25 unvaccinated animals in the herd. There is a 25% population growth per year.*
> *2019: With the 25% increase, the kudu population now consists of 125 individuals. If we don't vaccinate, only 60% of the herd of 125 kudus is now protected (50 unvaccinated kudus out of 125).*
> *2020: The herd increased to 160 individuals. Now only 43% is protected against rabies, BUT…, this vaccination was given already 2 years ago (how effective is the protection still?).*

By 2020 there is no herd immunity benefit left for this kudu population. This means that a once-off vaccination is quite useless, unless you give the population a booster vaccination.

Dr. Ulf Tubbesing
P.O. Box 50533 Bachbrecht, Windhoek
☎ +264 (0) 81 128 0350 ulft@africaonline.com.na
www.wildlifevetsnamibia.com

Some important considerations regarding vaccinating kudus and eland must be made:

1) It takes time for the immune system to make protective levels of antibodies (10-14 days), especially following a first time to disease or vaccine disease or vaccine.
2) Vaccines **do not kill** an infection! This means that kudus or eland that have been infected with rabies, are not cured by an emergency vaccination. They likely will die (remember, the body needs time to create the antibodies, with a rabies infection, the body does not have so much time)
3) When we vaccinate kudus and eland from the helicopter, it is impossible to dart every individual animal on the farm. Even under optimal conditions it is unlikely one reaches more than 80% of the population. This means that it is possible that some individuals die of rabies, even after a vaccination campaign. However, to create heard immunity, one needs to at least dart 60 to 70% of the population. Those members of the population that did not get vaccinated, get the "shelter" benefit from the vaccinated population, where they are less likely to come into contact with rabid animals, as they are surrounded by vaccinated animals.
4) Dart vaccination from a helicopter is costly but worth the effort. Occasionally farmers want us to only vaccinate kudu (and/or eland) bulls. This is an exercise in futility! It takes nearly as much flying time (and thus cost) to comb a farm for bulls as it does to vaccinate the whole herd BUT this kudu population certainly does not benefit from the effect of herd immunity! To only protect the end product (kudu trophy) without ensuring that the "production line" (the cow herd) remains functional does not make sense.
5) The rabies vaccine that we use has been scientifically proven to work in domestic animals (dogs, cats, horses, cattle and sheep). It is a dead vaccine which thus **cannot** induce rabies!

Our personal experiences with rabies dart vaccination is very positive. Over the past few years we have been vaccinating kudus and eland on a limited number of game farms in Namibia. These farms are the only farms in their district who can reliably offer trophy kudu bulls. In yet another experience, a few years ago, we vaccinated kudu and eland on a farm near Otavi after an outbreak of rabies. The outbreak was stopped. However, no follow-up vaccinations were done. Two years later, we were called out again to dart vaccinate the same kudu/eland population as there was a repeated rabies outbreak!

If you want to know more about rabies and herd immunity, have a look at the previous two articles: Rabies in kudu and eland #1: Implications to the game industry & Rabies in kudu and eland #2: Herd immunity in rabies and COVID-19 on our website.

Dr. Ulf Tubbesing
P.O. Box 50533 Bachbrecht, Windhoek
+264 (0) 81 128 0350 ulft@africaonline.com.na
www.wildlifevetsnamibia.com