Ticks

Tick Control

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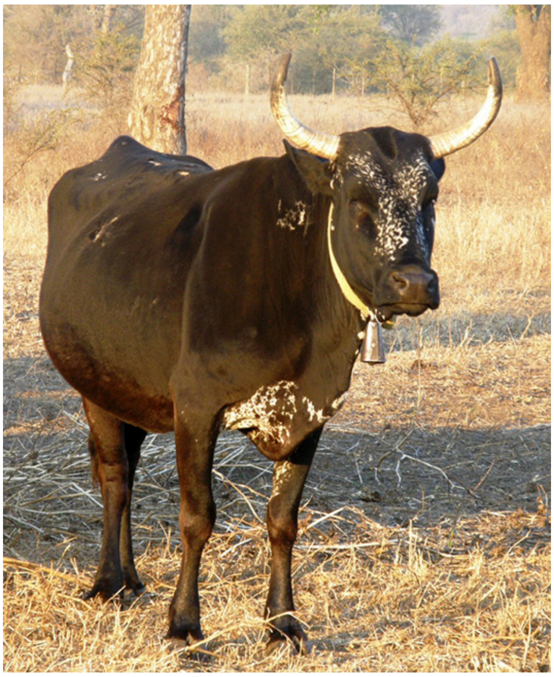
INTRODUCTION

Cattle have been present in Africa for thousands of years and until the twentieth century "survived" without specific control measures against ticks and tick-borne diseases. It is now known that the indigenous Sanga and Zebu breeds can develop some degree of resistance to ticks, and will also acquire immunity to tick-borne diseases if exposed to them at an early age. Sanga cattle (*Bos taurus africanus*), of which the Nguni is an ecotype, may have evolved from crosses between Zebu and humpless Hamitic Longhorn and Shorthorn cattle in central and east Africa around 1600 B.C. (Payne, 1964; Schoeman, 1989). Most losses due to tick-borne diseases occur in endemically unstable situations where there are insufficient infected ticks to ensure that all calves are challenged with the organisms causing the tick-borne diseases endemic to the particular locality. Endemic instability exists in areas that are only marginally suitable for the survival of the tick vectors or where tick populations have been suppressed but not eradicated through the use of acaricides. Tick-borne diseases also cause losses if livestock or wildlife are introduced, together with their ticks, to new regions and spread through susceptible local livestock populations, or if susceptible animals, especially exotic breeds, are moved to endemic areas.



Nguni cow, South Africa

IMPORTANCE

Many of the ticks and the diseases that they transmit are known to occur in specific geographical areas, but with globalisation and climate change constant awareness is vital to track the occurrence and spread of ticks and tick-borne diseases.

Failure to control ticks and tick-borne diseases effectively is a major factor limiting livestock production. The cost of worldwide economic loss and the additional burden of protecting livestock against ticks and tick-borne diseases is now estimated to be in the billions of dollars annually. Apart from the diseases they transmit, ticks *per se* also cause production losses or even mortality, especially when immense numbers are present on animals. In most cases, rearing of improved or "exotic" cattle breeds is difficult under extensive farming systems where contact between livestock, ticks and reservoir animals is possible. Although domestic animals are commonly considered to be the preferred hosts of ticks, many species would not be able to complete their life cycles without the presence of wildlife.

Globally, almost 900 species of ticks have been described, of which about 700 species are hard ticks and the remainder soft ticks. Approximately 200 ixodid and 40 argasid tick species are present in the Afrotropical region, but only a small number are of veterinary or human importance. Farmers are constantly being challenged with tick-related issues, such as control problems due to acaricide resistance, high susceptibility to tick-borne diseases of improved livestock, and cattle movements.

Concerned farmers after the import of *R. microplus* in West Africa

CONTROL

The future of tick control on domestic and wild animals lies in the integrated use of the available technologies such as chemicals, the management of acaricide resistance, host resistance, tick vaccines, and tick-borne disease vaccines, as it seems unlikely that any one of these is robust enough to stand alone (Willadsen, 1997). The concept implies the rational use of acaricides in combination with other technologies to cost-effectively minimise production losses caused by ticks and tick-borne diseases. Such a programme could include any number of the components listed below.

Chemical control with acaricides is the most commonly used method, applied in a number of ways as described below, but has led to the selection of tick populations that are resistant against a wide range of acaricides. Especially populations of the one-host ticks (*Rhipicephalus (B.) decoloratus* and *Rhipicephalus (B.) microplus*) are known to be resistant to almost every available acaricidal molecule. In addition, most of these chemicals are also toxic and expensive and their application costly. Furthermore, in areas with extremely high tick populations accompanied by pronounced acaricide resistance, chemical control is no longer sustainable and farming with local cattle breeds, especially for meat production, is more appropriate. As mentioned above, these breeds, mainly Sanga or zebu-type, have some degree of natural resistance to ticks and tick-borne diseases. However, for dairy purposes improved breeds still remain more popular in many African countries.

Grazing strategies

Avoid camps that are heavily infested with ticks during certain seasons. Thus sheep and goats must not be grazed in camps on the southern aspect of hills or mountains in the Karoo, South Africa during autumn and winter. The Karoo paralysis tick, *Ixodes rubicundus* is most abundant in this type of habitat and is present only from late summer to spring. In addition, goats and cattle can be grazed in sheep camps during summer to denude shrubs and keep the grass short thus eliminating favourable breeding or questing sites for the tick.

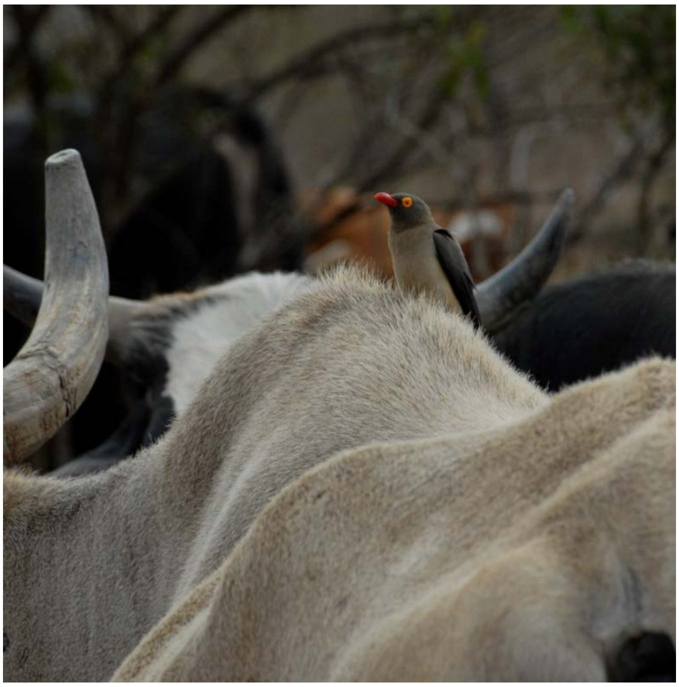
In the case of tick species that take a year to complete their life cycles, pastures can be rested from the end of the season of adult tick abundance until the commencement of the following year's season of abundance. Provided no hosts suitable for the immature stages are allowed onto the pastures during the intervening months, most of these ticks should have died and the numbers of adults present when the livestock are reintroduced should be minimal.

In much of southern Africa it is common practice to burn natural pastures once every 2 or 3 years during spring to control shrub invasion and remove dead plant material. These deliberate fires coincide with the post-winter synchronous hatching of *R. (B.) decoloratus* larvae and their questing on the vegetation and thus many are destroyed. However, the short-term effect on tick abundance does not compensate for the damage inflicted on some vegetation types by regular burning.

A high stocking density may initially favour the propagation of ticks because of the abundance of hosts. However, should stock numbers become too large the habitat may be damaged to such an extent that it becomes unfavourable for the survival of some tick species. Human perturbation of the environment by chopping down trees for firewood or removing them in order to establish pastures can have the same effect.

Tick vaccines

Problems of acaricide resistance, chemical residues in food and the environment and the unsuitability of tick resistant cattle for all production systems make the current situation unsatisfactory, and have forced researchers to look for alternatives. Tick vaccines seemed to offer a partial solution. Two similar vaccines were produced (Gavac® and TickGARD®), both using the same gene Bm86, a concealed gut antigen, to provoke an immune response in cattle to the one-host tick *R*. (*B.*) *microplus*. Although a high degree of immunity was obtained with the vaccine, immunity did not last long and vaccination needed to be repeated several times a year and had to be combined with acaricide application to reach an adequate effect against the tick burden on animals. The use of the cDNA expression library immunization (ELI) technique or RNA interference, two emerging molecular techniques, may assist in the identification of potential tick-protective antigens.



Oxpecker, South Africa

Similarly, immunization against tick-borne diseases can currently be accomplished by using blood vaccines containing infective or attenuated organisms or using infected tick stabilates. These vaccines will in the future undoubtedly be surpassed by recombinant antigens produced in transformed cells, or by chemically synthesized antigens.

Biological control

Many studies have focused on the biological control of ticks but so far no efficient methods are used on a large scale against ticks and it is unlikely that many of these agents will be commercially viable. Nevertheless under natural conditions these agents may play a significant role in reducing tick numbers.

Predators, parasites and pathogens

Among the natural predators yellow- and red-billed oxpeckers *Buphagus africanus* and *B. erythrorhynchus* are known to feed on ectoparasites and especially on ticks. However, some authors are not convinced of the benefit of having oxpeckers in the close vicinity of cattle as they create wounds and increase the size of existing wounds (Weeks, 2000). Chemical control of ticks has, however, resulted in drastic declines in the populations of these birds during the last century. This decline has resulted from the birds ingesting ticks that have been treated with an acaricide and also because the pool of ticks required by the birds to feed on in order to reproduce has been drastically reduced because of the use of effective acaricides. Other bird species such as domestic chickens and guineafowls can also reduce the number of questing ticks significantly, although ticks are not their main food source. Where cattle are penned close to rural dwellings at night indigenous chickens can be encouraged to roost close to the enclosures as this will facilitate tick predation. Small scale rural farmers often pen their cattle at night and the household chickens will pluck engorged ticks from these animals as well as consume those that detach to lay eggs. A single engorged female tick eaten by a chicken reduces the next generation of larvae by several thousand.

Parasitoids such as fungi or parasitic nematodes constitute another group of biological control mechanisms as do pathogens like the bacterium *Bacillus thuringiensis*. Because of their own susceptibility to environmental conditions, it is unlikely that fungi or nematodes will ever constitute a major control method for ticks. In the case of *B. thuringiensis* ingestion of the bacteria is necessary to have a pathogenic effect on the ticks, and this is only possible if the host is infected with the bacteria so that ticks ingest them with the blood of the host animal.

Some hymenoptera (wasps) (such as the widespread *Ixodiphagus hookeri*) are parasitoids of ticks, but they have little specificity for their tick hosts and their fertility is lower than that of the ticks. Development of the wasps' eggs in its tick host was found to be associated with ingestion of blood by the host tick. Inundative releases of these wasps have shown potential value, but the cost of such a programme is too high to be a realistic solution.

Host's resistance

It was noticed that within a host species, certain breeds (and cross-breeds) and within a breed, certain animals are capable of limiting the number of ticks on their body. This may be due to tick avoidance strategies, grooming, or by characteristics of their skin, or they may be resistant to tick infestation and limit the number of ticks surviving until maturity or limit the number of offspring of ticks that do survive.

This resistance may be present from the time of birth (**innate natural resistance**), but can also be progressively acquired in response to tick exposure. Acquired resistance develops because of the host's immunological reaction towards the exposed antigens of the parasite (**acquired natural resistance**). Innate resistance and the ability to acquire resistance are heritable and are not necessarily linked. Generally, individuals in a herd that are resistant to one tick species are likely to be resistant to others. Acquired resistance to one tick species, however, does not necessarily imply that resistance to other tick species can also be acquired.

The host's resistance is largely determined by the animal's physiological condition (it can deteriorate due to stress, disease, lactation, malnutrition) and it can fluctuate according to the seasons.

In order to maintain a level of resistance, it is necessary for an animal to have regular contact with ticks. This resistance is mainly based on allergic and immunological reactions to the tick's tissues and salivary secretions (enzymes, tick's cement, anticoagulants). Resistance is characterized by, among other things, a prolongation of the parasitic phase (especially in case of female ticks) and a reduction in the number of ticks that engorge completely and survive to maturity, a weight loss of engorged ticks and a diminution of their fertility. Tick feeding induces a complex array of host immune responses involving antigen presenting cells (e.g. Langerhans cells), T-cells, B-cells, antibodies, cytokines, complement, basophils, mast cells, eosinophils and a number of bioactive molecules. These complex interactions can be viewed as a balance between host defences raised against the parasite and evasive strategies by the ticks that facilitate their feeding (anticoagulants, modulation of host cytokine), counteracting host immune systems (e.g. immunoglobulin-binding proteins, interleukin 2 - and histamine-binding proteins, anti-complement protein) and potentiating transmission of pathogens (probably by immunomodulatory proteins in tick saliva).

There are differences in susceptibility between individuals within a breed, but still more between different breeds and species. In Australia, zebu cattle (*Bos indicus*) have proven to be more resistant to ticks than taurine cattle (*Bos taurus*), whereas crosses between the two species show intermediate resistance. In West Africa local taurine breeds (e.g. Ndama) have been selected naturally for resistance to ticks.

Sanga or Zebu cattle can be farmed with minimal tick control, ranging from none in dry areas to strategic wet-season control in higher rainfall areas, whereas *B. taurus* cattle require intensive tick control for the greater part of the year in all but dry areas. The amount of control required for crossbred cattle will be somewhere between these two extremes.

Especially in Africa there is a need to carefully plan the selection of indigenous cattle to attain the maximum benefit from their ability to acquire resistance to ticks. Cross-breeding with susceptible exotic breeds must also be carefully planned in order to avoid the loss of host resistance. In this process the productivity and tick and tick-borne disease resistance of indigenous breeds must be carefully evaluated. As a consequence of tick resistance in indigenous cattle, acaricide will be used less frequently, thus delaying the development of acaricide resistance. For developing countries, where livestock breeding does not aim at rapid and high production goals, the strategy of selecting for resistance in indigenous breeds is probably more rewarding than increasing tick resistance in susceptible exotic breeds by practising hybridization.

African buffalo (*Syncerus caffer*), South Africa

Resistance to the nymphs and adults of *A. variegatum* and *A. hebraeum* seems to be less efficient than it is to other African ticks: *R. (B.) decoloratus* and *R. evertsi.* Immunosuppressive substances in the saliva of the Amblyomma spp. are possibly to blame.

African buffaloes, *Syncerus caffer*, acquire resistance to *R. (B.) decoloratus* at approximately one year of age. It would, however, appear that they do not acquire resistance to infestation with any stage of development of *A. hebraeum* as they may harbour thousands of larvae and nymphs and hundreds of adult ticks of this species. Resistance by buffaloes to adult *A. hebraeum* is displayed in the fact that although they may harbour hundreds of ticks very little damage to udders, teats and other soft tissue is noticeable compared to the severe damage caused by this tick in cattle.

NOTE:

Host resistance also means that female ticks have a prolonged parasitic phase. It is thus possible that proportionally more females can be found on resistant animals than on sensitive ones.

Initially the development of the host's resistance will be at the cost of productivity.

When one compares the resistance to ticks of different breeds, it is important to make sure that the difference in the number of ticks between the two breeds is not a consequence of the difference in size between the two breeds.

Pasture spelling

This method has given satisfactory results in Australia, where it has been shown that it is possible to reasonably control, at least under certain circumstances, *R. (B.) microplus*, if one changes pastures every 3 or 4 months.

In principle, the method is based on the life cycle of *R. (B.) microplus,* whose larvae die rather soon if they don't find a host in the weeks following their emergence, and whether the pastures are homogenous without any shelter for the ticks to protect themselves against harsh climatic conditions.

There are of course several conditions for this strategy to succeed:

- cattle must be the exclusive host of the ticks, which is the case for *R. (B.) microplus* and
- there must be sufficient pastures and enclosures available.

It is immediately clear that this system cannot be applied everywhere.

In practice, rotation is applied in combination with strategic acaricide treatment; the method considerably reduces the number of treatments (7 instead of 20 for *R. (B.) microplus* in Australia). The animals are treated just before their transportation to another pasture. The latter practice has a distinct disadvantage if the *R. (B.) microplus* are acaricide resistant in that only resistant ticks and no susceptible ticks will be transported onto to the fresh rested pasture.

When ticks constitute a complex fauna of several species as is the case in Africa, their management is far more difficult. It has been observed that larvae of *A. variegatum* can survive up to 11 months and adults up to 20 months. Periodic flooding of the pastures of the plains (mbuga in Tanzania, dambo in Zambia/Malawi, vlei in South Africa) reduces the infestation by ticks of the animals grazing these pastures because of the disturbance in the ticks' developmental cycle.

Transhumance, as practised in certain areas in Africa, is actually another form of pasture rotation but can also be a way of introducing ticks into new areas.

In Brazil it was observed that successive grazing of cattle followed by sheep strongly reduces the *R. (B.) microplus* populations on these pastures as the tick feeds less readily on the latter host.

Habitat modification

Bush fires in the tropics usually occur in the dry season, at the time that tick larvae and or nymphs are questing for hosts. It is thought that in general the tick population doesn't suffer much from the passing fire, unless it is slow, hot and consumes the lower vegetation. If major hosts are reintroduced shortly after the fire any tick reduction benefit that might have accrued from the fire will be lost. Regular bush fires can have a negative effect on tick densities by preventing the growth of long grasses. They can, however, also have a negative effect on the species composition and nutritional value of the surviving vegetation.

Bush fire (http://blog.wildlife-pictures-online.com)

The elimination of unwanted vegetation will also destroy the habitat of native small vertebrates acting as hosts in the immature stages of certain ticks.

Ploughing, as well as the grinding and burning of bush, constitute additional measures for effective tick control through exposing the soil and thus the surviving ticks to sunshine. Cultivation has a negative effect on those tick species (*A. hebraeum*, *A.cajennense*) that depend for their survival on the shade of trees and tall grass. The replacement of natural shrub vegetation with prairies of 'kikuyu' has led in some areas to the disappearance of *A. hebraeum*.

Chemical control

Strategic control

Acaricide is applied during strategic times of the year in order to control seasonal peaks in tick abundance. It is aimed mainly at adult ticks to decrease numbers to levels at which economic damage is less than the cost of control.

Opportunistic control

Acaricide is applied only when tick numbers are considered to exceed the economic threshold. This strategy is effective when animals possess a high level of immunity (resistance?) to ticks or in regions where ticks are only sometimes a problem because of favourable climatic conditions.

Selective control

Only those animals with tick burdens considered to be above the economic threshold are treated. This is more easily achieved with small herds of cattle and should both reduce treatment costs and delay the appearance of acaricide resistance. Individual animals that continuously harbour very high tick burdens should be culled as they are likely to pass this trait on to their offspring.

Alternation

Acaricides from different chemical groups or acaricide combination formulations are applied alternately. The inclusion of acarine growth regulators in this regimen may further help delay the development of acaricide resistance.

Management of acaricide resistance

When resistance is already present, animals must not be treated with an acaricide from the chemical group to which resistance is evident before moving them to clean or rested pasture, as this will result in the new pasture becoming contaminated with resistant ticks only. An acaricide from a completely different group should be used in such an event.

Acaricide application to livestock

Ticks are the most important ectoparasites of cattle and depending on the severity of infestation, some form of control against them might have to be applied throughout the year. The majority of adult ticks are most active in summer and more than one species and different developmental stages may be present on animals at the same time during this season, e.g. adult *A. hebraeum* and adult *R. appendiculatus*, all stages of development of *R. evertsi evertsi* and all stages of development of *R. decoloratus* (blue tick) frequently occur on the same animal. The intervals between applications of acaricide will depend on the tick species concerned and to be really effective should not exceed the fastest feeding time of any of the ticks present. The ideal is that every tick must come into contact with acaricide before it engorges and drops from the host.

The time that the developmental stages of ticks spend on the host varies with the species, e.g. *R. appendiculatus* is a rapid feeder and each stage can engorge within 4-7 days. All stages of the one-host ticks *R. decoloratus* and *R. (B.) microplus* remain on a single host throughout their parasitic developmental stages and these are attached for 21-24 days before the engorged females drop off. The adults of *Hyalomma* spp. *Amblyomma hebraeum* and *R. evertsi evertsi* are attached for 7-14 days and immatures of *R. evertsi evertsi* are attached in the ear canal for 14 days. Unless compounds with a residual effect are used, dipping animals every 7 days would therefore be adequate to control all the above-mentioned ticks except *R. appendiculatus*. When *R. appendiculatus* is to be controlled the dipping interval must be reduced to 4-5 days if compounds without a residual effect are used.

Dipping may have to be continued throughout the year as many species continue reproducing in the winter, e.g. *A. hebraeum*, *R. evertsi evertsi* and *R. (B.) decoloratus* continue breeding at a slower rate in winter in the lowveld and bushveld of South Africa. The numbers of larvae of *R. appendiculatus* reach a peak in autumn and winter and the nymphs in winter and spring. These developmentalstages are small and not easily seen so that farmers stop dipping or do so infrequently in winter. This may result in a build-up of tick numbers in the summer. In equatorial Africa ticks are active throughout the year and continuous control of ticks might be required. After the introduction of *R. microplus* into coastal areas of West Africa (Madder et al., 2007, 2011), large numbers of this tick caused considerable production losses even when frequent tick control measures were applied, most probably because of the combined effect of acaricide resistance and inadequate dosage and frequency of acaricide application.

Preparation of the dipping solution at the dip tank

Methods of application of acaricides to cattle, sheep and goats

Spray race

The advantages of a spray race are:

- The dip wash is always at the correct strength and fresh and evenly suspended in the fluid because it is made up at each dipping.
- The cost of the acaricide is spread evenly throughout the year or season.
- Acaricides may readily be alternated.
- Injuries to the animals are unlikely to occur.

The disadvantages of a spray race are:

- Mechanical failure of the pump.
- Wetting is not always complete, particularly of the ears and under the tail.
- The stripping rate is high, resulting in a lower concentration of acaricide by the time the last animals are treated. Stripping implies that a higher concentration of acaricide clings to the animals and that the concentration of acaricide in the fluid that drips off the animals after they have been sprayed and that flows back into the sump is lower than that in the original spraying suspension.

Practical considerations

- The spray race must not be built close to water sources as these may become contaminated by run-off from the sump.
- It must not be built near deciduous trees.
- The walls must be built across the direction of the prevailing wind and the spray race should be roofed.
- In the southern hemisphere if possible the animals should enter the race from the north so that they are not dazzled by the sun shining through the spray-mist.
- There must be a footbath before the entrance to the race. Preferably the floor of the footbath should be cobbled to spread the claws and thus help remove mud, and dipping fluid should be added to the footbath to assist in the control of the adult and immature stages of ticks that prefer the feet as a predilection attachment site.
- The draining race must be long so that spraying is not interrupted while allowing for draining and hand-dressing.
- Sieves between the spray race and the sump and those between the draining race and the sump must fit properly and be effective. They must be inspected regularly during spraying to ensure that they have not become clogged.
- The sump must have a capacity of 600-1500 liters (2,5 liters per animal) and must be calibrated.
- A maximum of 500 animals should be dipped with a single sump full of dipping fluid. If more animals are to be dipped the sump should be refilled with a freshly prepared suspension of acaricide.
- Dipping fluid must be delivered at approximately 700 litres per minute at a pressure of 1.4 bar.
- All the nozzles and sieves must be in working condition before dipping commences.
- To ensure that the peri-anal region is thoroughly wetted wave a tennis or solid racquet in front of the animals as they come out of the spray race. This will cause them to stop and lift up their tails.

- All the pipes and the sump must be flushed with clean water after use.
- If horses are to be sprayed they must be accustomed to the spray race before it is turned on fully - they must pass through with the pump off, then with the pump half on and finally at full strength.

Plunge dip or dipping tank

The advantages of a dipping tank are:

- The wetting of the animals is good.
- The stripping rate is lower than in the spray race: the dip concentration is more stable during dipping.

The disadvantages are:

- An adequate source of clean water must be readily available to fill the dip initially and to ensure that top-ups can be made when required. This is often not possible in arid and semi-arid regions.
- It requires a large initial capital outlay to fill the tank with acaricide.
- Acaricides cannot be changed regularly.
- The dipping fluid is often dirty and old and the strength is not known.
- The concentration in the dip tank may change as a result of flooding or evaporation.
- The suspension settles in the interval between dippings. Therefore 20 animals must be sent through to mix the fluid and these animals must be re-dipped. Alternatively, relatively large holes can be drilled in a circular plowshare, the centre of which is then welded to a metal pipe. The plowshare is then dunked to the bottom of the dip and pulled up again and the procedure repeated until the dip is well mixed.
- The animals may be injured.

Plunge dipping

Video: plunge dipping (http://youtu.be/eFggBwL6CjY)

Practical considerations

- The dip must be constructed close to a reliable source of clean water for filling and replenishment.
- The dip must not be built in a hollow as flooding may occur. High-lying ground on a slope is preferable.
- It must not be built near deciduous trees or water sources.
- The animals must pass through a foot dip which is long and narrow. It should be divided into 2 sections as an undivided foot dip soon becomes a pool of mud. It must not drain into the diptank.
- The tank should be roofed to prevent evaporation or dilution.
- The entrance should be narrow, so that the animals enter singly, and raised, so that the hindquarters are higher than the head for proper plunging. The edge of the basin should be rounded to prevent injury to the animals when jumping.
- A heavy, waterproof canvass curtain about 3 metres from the jump-in point, hanging across the space between the splashwalls to 45 cm above dipwash level, will force cattle to dive downwards as they can see only a small pool, thus wetting their heads.
- The ideal size for a plunge dip is 9 000 - 15 000 litres so that the dip fluid can be replenished regularly and frequently.
- The dip tank must be calibrated at 200 - 500 litre levels and the critical level clearly marked - when the dip fluid falls below this level the animal is not thoroughly wet.
- The exit must have a good grip for animals moving forwards and upwards and the exit point should be raised to prevent storm water from entering the tank.
- The drip-off area should be long and have a non-slip floor. The return flow from the drip-off area should enter the tank through a sump in which the debris may sediment or be strained off by sieves.
- There should be a working race preferably provided with neck clamps to hand-dress and otherwise treat the animals.

- Animals must be dipped slowly so that they are thoroughly wet and ticks on them exposed to the dipping compound for as long as possible.
- A dipping register must be kept recording the volume of water and dip used to fill the tank initially. Thereafter the volume of water and dip added for replenishment must be recorded, as well as the numbers of animals dipped at each occasion. The level of the dip in the tank must also be recorded before and after each dipping so that evaporation and rainfall can be taken into account.
- If samples are to be taken to test the dip concentration these should be collected in clean glass bottles from below the surface of the dip before the commencement of dipping, half-way through dipping and after the last animal has been dipped. The bottles must be clearly labelled accordingly.

Calculation of dipping costs for a plunge dip

- For example if 500 cattle are dipped 40 times a year for 2 years in the same dipping fluid - this is the average time between emptying, cleaning and refilling a plunge dip in South Africa.
- Capacity of plunge dip = 15 000 litres
- No. of cattle at each dipping = 500 (a)
- No. of dippings per annum = 40 (b)
- Time period = 2 years (c)
- Fluid removed per animal = 2,5 liters (d)
- The water replenishment will be -
  a x b x c x d = 500 x 40 x 2 x 2,5 = 100 000 litres
- The acaricide is diluted 1:1000 for original filling and 1:800 at each replenishment.
- The amount of acaricide used is:
  1:1000 for 15 000 liters = 15 litres
  1:800 for 100 000 liters = 125 litres
- 500 cattle therefore require 140 litres of acaricide over a 2 year period and each animal requires 0,28 litre of concentrated acaricide
- Assume the acaricide costs R40-00 per litre, it will cost R11-20 to dip an animal 40 times per year for 2 years (80 dippings) or 14,0 cent per dipping.

Hand dressing

The pesticide is usually applied with a brush to the area to be treated (frequently the ears and under the tail). Directions on the strength to be used for hand-dressing are usually provided on the label. Tick grease may coat the treated area with a layer of grease and prevent the pesticide used at subsequent dippings from wetting the area. Tick oil is easier to apply and does not coat the area for such a long period. Aerosols may also be used to treat the infested area.

Hand spraying

A high pressure hand pump is used. This method is used when fewer than 20 animals are to be treated as 10-15 litres of dipping fluid must be used on each animal to ensure proper wetting. The fluid that drains from the animal is generally lost, as the run-off is not collected. The animals should be immobilized when treated to be able to reach all the predilection sites of the ticks on the animals, particular attention being paid to the ears and under the tail. Under-dosage and incorrect application can easily lead to acaricide resistance in ticks.

Video: hand spraying, Benin (http://youtu.be/GgzeTdYLp00)

Pour-on

The acaricide, in a formulation containing effective spreaders, is administered along the top-line from the poll to the tail base. Pour-ons can be used when there are few or many cattle to be treated and require only a crush pen for handling the animals. Some of the endectocides administered as pour-ons are absorbed through the skin and reach their targets in this way.

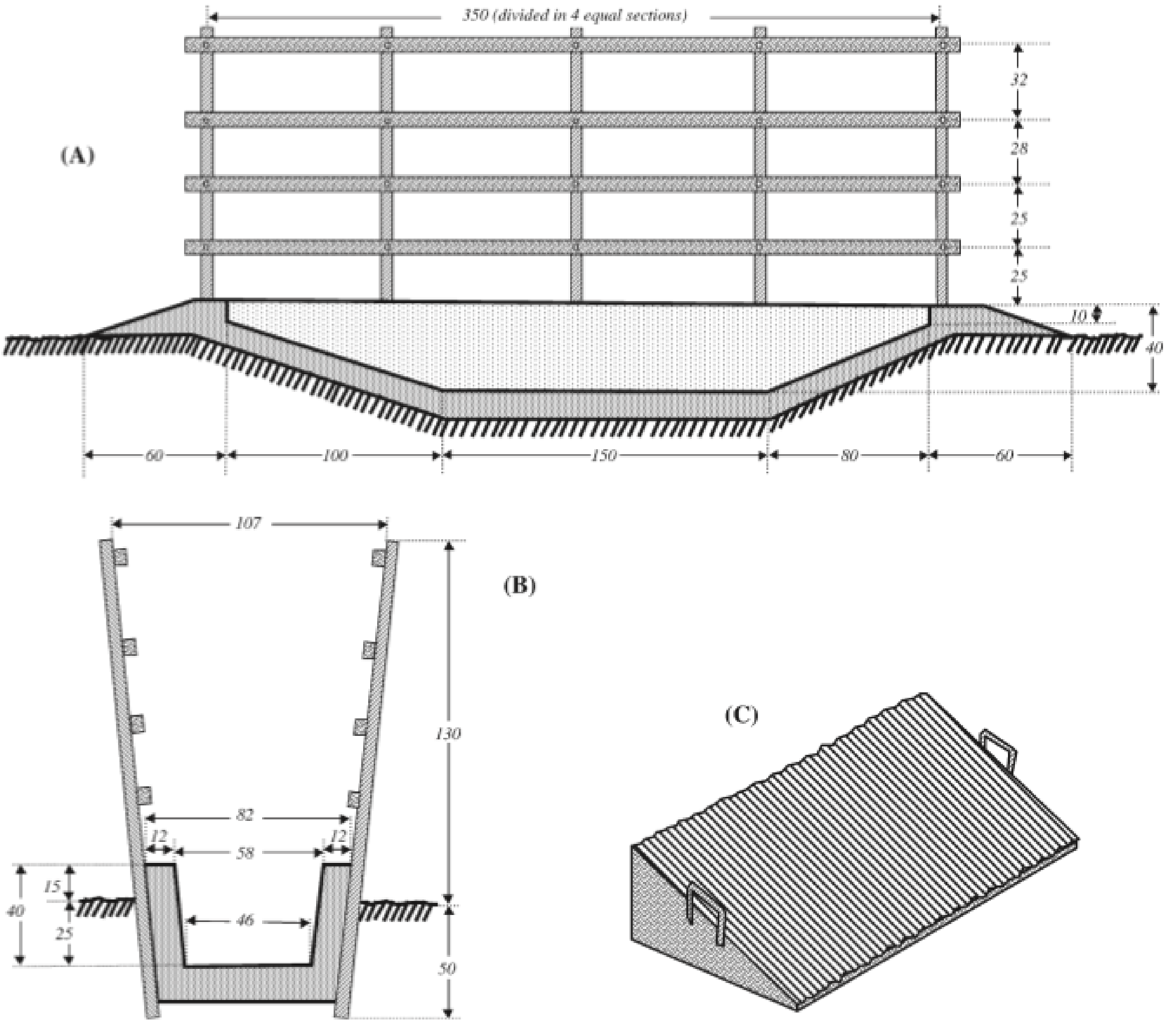
Self-treatment

The Duncan applicator is an example of this method of acaricide application. The cattle are attracted to a lick in a drum and their ears, faces and necks come into contact with a pour-on formulation of acaricide running down a grooved steel pole in the centre of the drum from a canister at the top of the pole. The animals spread the acaricide over the rest of their bodies while grooming. Similar devices have been developed for wildlife. The 4-Poster" Deer Treatment Bait Station has been developed and licensed by The American Lyme Disease Foundation (www.aldf.com). It targets the white tail deer, the key host for the ticks that transmit Lyme disease. By using the 4-Poster Deer Treatment Station an approved tickicide can be applied to the head and neck areas of white tail deer while they feed. The head and neck area has been shown to be where 90% of the feeding adult ticks are located on the deer (www.crdaniels.com).

The 4-poster deer treatment bait station (http://www.aldf.com)

Footbath treatment

Studies have shown that about 90% of adult *Amblyomma variegatum* picked up daily by grazing cattle are still attached to the interdigital areas in the evening, when the animals return from pasture. When the animals lie down, the ticks would then move to other predilection sites such as udder/inguinal area and chest (Stachurski, 2006). It was therefore postulated that a targeted treatment, designed to kill the ticks attached to the feet, would limit infestation of the predilection sites (Stachurksi & Lancelot, 2006). Footbath treatment would also be practised in the Eastern Cape Province of South Africa against *Rhipicephalus glabroscutum* of which all stages of development attach around an between the claws resulting in secondary bacterial infection and foot abscess particularly in Angora goats.



Plan of the footbath used for acaricide treatment of cattle in the Bobo-Dioulasso area (Burkina Faso). (A) Longitudinal section. (B) Cross-section. (C) Profile view of one of the two half-roofs placed on the bath when not in use. (From Stachurski and Lancelot, 2006).

Pesticide application to wildlife

Tick control on wildlife in nature reserves encompassing more than 20 000 ha should not be necessary, particularly if a sustainable number of large carnivores are present to remove stressed, weak, sick or injured animals. Problems with ticks usually occur in small wildlife reserves or on game farms, especially those under 1 000 ha in size, on which it is not practical to also keep the larger wild carnivores. Healthy wild antelopes and equids in Africa normally harbour tick burdens in excess of several thousand. However, with the exception of large animals such as giraffes, African buffaloes and eland, which may harbour large burdens of adult ticks, the majority of ticks on wildlife are usually larvae and nymphs. Severe adult tick infestations on wildlife are therefore frequently an indication of some underlying management problem. This might be gross overstocking, or overstocking with particular species such as eland, which are large animals that are highly susceptible to tick infestation, particularly with adult ticks. It could also be due to the introduction of wildlife species not indigenous to a region and hence not adapted to the local tick species. In the latter event these animals may not only acquire enormous tick burdens but could also succumb to diseases such as heartwater or one of the theilerioses endemic to the locality into which they have been introduced.

Before control measures are instituted, the underlying cause of the problem should be addressed. One of the first steps in this direction would be to permanently remove any animals that are visually very heavily tick infested as well as any diseased or weak animals. The latter animals are normally severely stressed and consequently harbour very large tick burdens that can lead to contamination of their surroundings. Provided the habitat is suitable, the introduction of species such as blue wildebeest could be contemplated. These animals have an innate resistance to ticks and remarkably few adult ticks are found on them in their natural habitat. The introduction of oxpeckers can also be considered. This would only be feasible if the farm or reserve was located in a suitable habitat and was large enough to accommodate the birds, or if the surrounding cattle farmers use only acaricides that are not toxic to the oxpeckers. Although fire may kill large numbers of free-living ticks present on the vegetation at the time, its long-term effects seem to be limited, particularly if animals are not excluded from the burnt area once there is a flush of new vegetation.

Should chemical tick control be required acaricide can be administered by means of a self-medicating applicator coupled to a bin containing licks or food concentrates to which the animals are attracted (Duncan applicator). In South Africa several wildlife species are more inclined to take supplementary feed in such bins during the winter months because of the seasonal shortage of grazing. Consequently mainly immature ticks will be killed as these are abundant during the colder months of the year when adult ticks are present only in low numbers or not at all. Acaricide can be automatically applied to animals by constructing a single entrance to a watering point, thus forcing them to step on a pressure-plate or interrupt a light beam that will activate a jetting or pour-on device. Domestic cattle that are regularly treated with an acaricide can also be used to control ticks on a small wildlife reserve. These animals can be introduced in the wet summer months when adult ticks are most abundant and can be herded during the day into those parts of the reserve where ticks are deemed to be most numerous and then be treated with an acaricide at weekly intervals. No new wildlife should be introduced on to a wildlife reserve or a game farm without having first been thoroughly treated with a reliable, broad-spectrum acaricide. This will reduce the risk of introducing ticks into a region in which they did not previously occur as well as eliminating the stress of pre-existing tick burdens on the new introductions.

The regular treatment of domestic animals on mixed cattle and game farms can result in a significant reduction in tick numbers on the wildlife on the farm. Those tick species that use cattle as hosts for all their developmental stages, or that prefer cattle as hosts for their adults are particularly affected by this procedure.

In the Eastern Cape Province of South Africa, kudus on a farm on which cattle were treated with an acaricide harboured an average burden of 19 *Ablyomma hebraeum* including all stages of development, scrub hares on the same farm an average burden of less than 1 tick, and guineafowls an average of 36 immature stages of *A. hebraeum*. On the adjacent wildlife reserve the average burden of *A. hebraeum* on kudus was 1318, on scrub hares 53, and on guineafowls 464 ticks. In the Central Province of Zambia, impalas on a farm on which cattle were treated with an acaricide had average total burdens of 134 ticks compared to an average total burden of 4407 ticks on impalas on a game ranch without cattle?.

Biological tick control in wildlife

Self- and allogrooming: impalas can frequently be seen grooming themselves and other impalas by sliding their loose pairs of incisor teeth through their hair. The third and fourth incisors of impalas and the inner toe of hindfeet of dassies have been "adapted" to facilitate grooming. Rhinos and warthogs use mud-wallows and rubbing posts to rid themselves of ectoparasites including ticks. Rhinos will also rub their inner thighs, scrotum and udders on a rock or post of convenient height. Such rocks and posts eventually become quite smooth.

A rhino rubbing post (www.magical-southern-african-safaris.com).

Oxpeckers scissor their beaks through the hair of animals to which they cling collecting lice and the immature stages of ticks. They also prefer engorged females of the short mouthpart ticks such as *R. (B.) decoloratus.*

Starlings are opportunistic predators of ticks. This happens particularly during the winter in the Mountain Zebra Park, Eastern Cape Province in South Africa when food sources are scarce and starlings then opportunistically pluck *Margaropus winthemi* off zebras that are heavily infested with this tick during winter.

Turtles and fish may also remove ticks and other extoparasites from buffaloes crossing rivers and rhinos wallowing at the edge of larger water sources.

Some wildlife species such as blue wildebeest are innately resistant to tick infestation from birth.

Chemical tick control in wildlife

This can be accomplished by acaricidal feedblocks, medication of preferred food items, capture and administration of long-acting antiparasiticides, darting with antiparasiticides, Duncan applicator, self-application via pressure or light sensitive apparatus, "flooding" an area on a game farm with cattle which are then dipped, and using pheromone and acaricide impregnated tail tags.

ACARICIDE RESISTANCE

Resistance to acaricides is the ability in a strain of ticks to tolerate doses of acaricides that would prove lethal to the majority of individuals in a normal population of the same species.

Some species have a natural resistance to insecticides. The reasons for this might be impermeability of the cuticle; behaviour traits - they may be repelled by the insecticide; and physiological processes make them not susceptible to the effect of the particular insecticide.

Natural resistance is present at the outset in all individuals of the species and does not develop as a result of acaricidal pressure. In a population of ticks there are those individuals that are more robust and are better equipped biochemically to counter the effects of acaricides. This ability is not necessarily passed on to their offspring.

Genetic resistance of ticks spreads by the reproduction of resistant individuals that have survived acaricidal concentrations insufficient to ensure the death of all. The acaricide acts as a selective screening process which concentrates resistant individuals already present in a population. The resistance is hereditary and the original heterogenous population is selected by acaricidal pressure to become a homogenous resistant population.

Resistance is not an adaptation that develops because of exposure to acaricides, but spreads because resistant genotypes already present in the population are favoured. The population carries the factors for resistance in low frequency before the acaricide was applied and resistant individuals are therefore selected by the application of the acaricide.

Truly sublethal concentrations of an acaricide, which do not kill a single individual, cannot select for resistance because they do not favour the genetic material available. Conversely acaricides used at a concentration that will kill each exposed individual cannot select for resistance as no individuals will escape. The selection of resistant strains is a function of acaricide concentrations between these two points. An entire population of arthropods will not become resistant in one generation - this is a process that requires several generations.

The more heterogenous a population is initially, the greater the possiblity of finding resistant individuals. The higher the selection pressure the more rapid the spread of resistance in the population.

Acaricidal pressure is also the number of times an individual or its offspring are exposed to the acaricide during their lifetimes or particular portions thereof. The blue tick, which spends 23 days on the host animal, is thus exposed to a higher acaricide pressure with regular weekly dipping than is the brown ear tick which only spends approximately 5 days on the host in each of its three developmental stages.

When resistance against a particular acaricide has become established in an arthropod strain it can only persist provided homozygosity exists throughout the strain. Resistance may be conferred by a single gene or may be polygenic and one or more chromosomes may be involved.

The rapidity with which resistance spreads through a population is dependent upon whether it is conferred by an incompletely recessive or a dominant gene.

Acaricide resistance is a function of gene-modified enzymes. This may involve:

- Altered cuticular biochemistry which retards the entry of acaricides.
- More rapid enzymatic degradation of the acaricide before it reaches the target area.
- Modification of cholinesterase, which renders it less sensitive to inhibition by the acaricide.

Cross-resistance to acaricides that act in the same way does occur. Thus ticks resistant to DDT may also be resistant to the pyrethrins and the synthetic pyrethroids. There is also cross-resistance between the various organophosphates.

TICK CONTROL – ENDEMIC STABILITY OF TICK-BORNE DISEASES

Finding the equilibrium between endemic stability and ticks control is not an easy task. Endemic stability is an epidemiological state in which clinical disease is low despite high levels of infection in the population (Coleman et al., 2001). To achieve this, a sufficiently high number of infected ticks are necessary on the animals [high Entomological Inoculation Rate (EIR)] at a young age to ensure exposure to the pathogen before colostral and innate immunity disappears. The high levels of protective immunity therefore reduce the prevalence of disease in older animals. For most tick-borne diseases this age is around 9 months. This corresponds with an EIR of 0.01 i.e. the number of infected tick bites per day per animal. Below this level instability occurs resulting in a higher disease incidence.

There are, however, two requirements to achieve endemic stability as described above:

- the probability of severity of clinical disease resulting from infection increases with age; and that
- after first infection, the chance that subsequent infections result in clinical disease is reduced (Hay, 2001).

It is clear that tick control can influence the endemic stability state of a host population. Intense and successful tick control but without eradication of the tick vector can lead to an unstable epidemiological situation as a result of a lower EIR, resulting in a lower seroprevalence and eventually higher number of clinical cases.

Several researchers have studied the effect of dipping systems on endemic stability to bovine babesiosis and anaplasmosis in cattle in communal grazed areas in buffer zones adjoining the Kruger National Park in South Africa (additional reading: Rikhotso et al., 2005; Stevens et al., 2007, “Endemic stability.pdf)”. In general, intensive dipping reduced the tick load on the animals and probably also the tick load on the vegetation and consequently also reduced the transmission of tick-borne pathogens like *Babesia*, lowering the seroprevalence in cattle.

CHEMICAL TICK CONTROL MANAGEMENT

Frequency of treatment

Chemical tick control is mainly carried out by applying acaricides to the animal. On one hand, the frequency of treatment depends on the duration of the tick’s parasitic cycle and the residual effect of the product, and on the other hand, this frequency also depends on the strategy that one considers using (prophylactic treatment or treatment when the intervention threshold is passed).

Systematic prophylactic treatments

Systematic prophylactic treatments are used when:

- one wants to prevent high mortality among susceptible cattle due to diseases transmitted by ticks and/or
- host resistance of local cattle to ticks is so weak that the tick populations rapidly reach dangerous levels.

However, if eradication of ticks is not achieved in these situations, the control must be continued involving considerable costs and may result in the development of acaricide resistance.

Presence of alternative hosts for ticks can also pose a problem and hamper tick eradication.

If cattle are not immunised in this situation a constant supply of acaricides must be guaranteed in order to protect the cattle.

In the past some governments have imposed and subsidised systematic prophylactic treatments, which in those countries resulted in breeders not being interested in tick-resistant breeds, nor in immunisation of susceptible cattle. Therefore, cattle there are generally very susceptible to tick-borne diseases.

Prophylactic treatments aim at interrupting the contamination of grazing land, which means that the intervals to be observed between treatments are important.

In one-host ticks (e.g. *Rhipicephalus* (*Boophilus*)) which have a parasitic cycle (on the animal) of about 3 weeks, an acaricide with a three-day residual effect will prevent the occurrence of engorged females on the animal for 24 days. In this way treatment would only be necessary every three weeks. Nevertheless, it seems that in practice nymphs moulting at the time of treatment very often are not killed, but their moulting period is prolonged. Due to this fact, adults arising from these moulting nymphs sometimes appear after the residual effect period of the second treatment. In common practice it seems to be indicated to carry out treatment on a bi-weekly basis with products having a residual effect of 3 to 4 days. Products with a long-term residual effect can allow 3 to 4-week intervals.

In the case of ticks with 2 to 3 hosts, control focuses on the parasitic period of adult females. This period varies from 4 to 5 days for the species which feed rapidly e.g. *Rhipicephalus*, and 8 to 10 days for slow-feeding species such as *Amblyomma spp.*. If one agrees that after treatment the residual effect period of the acaricide again lasts 3 to 4 days before an adult tick can survive on an animal, one could detect the first engorged females by the 8th day after the treatment. Thus if the animals are treated on the 7th day after the first treatment, the ticks will be killed before being able to gorge themselves. The products with a long-term residual effect allow intervals of 2 to 3 weeks.

Strategic prophylactic treatments:

These treatments aim to control the tick population by treating domestic animals at certain strategic periods of the year (usually at times when the adult population is important). By doing so, one tries to break the cycle of the ectoparasite.

In most farming situations using cross-bred (*B. taurus* x *B. indicus*) beef cattle, as well as in developing smallholder dairy systems that also use cross-bred cattle, strategic tick control would appear to be ecologically and economically feasible.

These categories also form the primary target for immunization programmes.

Duration and frequency of treatment will vary according to the ecoclimatic zone and tick challenge (both in terms of numbers and species), the breed and type of animal, the relative costs of control measures and the value of animal products. Assessments will have to be made initially from available field and experimental data for tick damage and productivity and then verified under local conditions. Computer modelling may assist in these assessments. The presence of a considerable number of alternative hosts or of farmers in neighbouring regions not implementing any tick control can cause this method to fail.

Treatments applied beyond the useful intervention threshold:

This method is used when the tick population only causes intermittent damage as is the case for *R. microplus* on zebu x *Bos taurus* in subtropical zones or for ticks with 3 hosts on zebus or local *Bos taurus*. Under conditions of enzootic stability, whether induced or occurring naturally, the implementation of threshold tick control may be justified. Sometimes it is sufficient to treat only those animals of the herd that are carriers of a considerable number of ticks. Where the tick numbers are below the useful intervention threshold, the ticks will not be controlled. Immunisation against tick-borne diseases will also be necessary where tick numbers are insufficient to maintain endemic stability. Annual or periodic adjustments need to be made based on prevailing costs. Where immunization is practised, its costs should be included in the initial analyses.

CHEMICAL PRODUCTS

Not all insecticides are suited for use as ixodicides, stability as well as residual effect are important.

Because of the diluents and stabilisers that are incorporated a commercial preparation is generally superior to a simple dilution of the active agent. It is absolutely indispensable to strictly follow the instructions of the manufacturer that are on the label and/or package insert.

Pesticide formulations

1. Dusting powders: These are used mainly on pets but occasionally also on larger animals. The active ingredient is diluted with an inactive powder.
2. Soluble powders: Arsenic is the only example.
3. Wettable powders (W.P.): These form suspensions in water and some of the dipping compounds are formulated as wettable powders.
4. Emulsifiable concentrates (E.C.): Are concentrated formulations which form emulsions in water, most dips are formulated in this way.
5. Impregnated strips: Absorbent strips are impregnated with insecticides which are liberated either in gaseous or crystalline form. Tick and flea collars and fly strips are examples.
6. Aerosols: The pesticide is incorporated in a vapour under high pressure. Household aerosols and acaricidal aerosols for patch or hand treatment are examples.
7. Oral formulations: These frequently also have anthelmintic properties.
8. Parenteral formulations.
9. Slow-release formulations.
10. Pour-on.

The acaricide formulations most commonly encountered are:

- on one hand the wettable powders (acaricide in very fine powder + non-active solvent + wetting agent, which allows the dust to be suspended in water –> suspension in water), and
- on the other hand the emulsifiable concentrates (an acaricide dissolved in an organic solvent + an emulsifier = a surface-active-agent used to stabilize a mixture of one liquid suspended in a larger amount of a second liquid –> emulsion in water).

The wettable powders seem to be the most stable formulations though not always the most efficient ones. They are less susceptible to stripping (the impoverishment when the acaricide concentration of the liquid that streams down from the animal is lower than the concentration in the pool) and they are usually less dangerous to handle since they are less easily absorbed by the skin. This formulation is particularly indicated for the dipping tank. It is useful to first prepare a paste with the acaricide powder and a bit of water before adding this paste to the bulk of water.

The use of emulsions is to be preferred in spray races. Emulsions have the advantage of not blocking up the nozzles as easily as the wettable powders do. They are directly added to the water and thoroughly mixed.

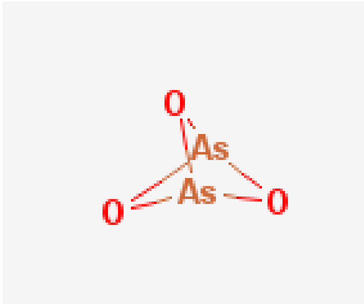
Never use phytopharmaceutical products! Although the acaricidal effects of many different plant extracts have been demonstrated (mostly *in vitro*), these have not been sufficiently standardised or tested for safety and efficacy to be commercially viable.

Take into account that in most countries the cost of acaricides includes a significant foreign exchange component!

Arsenicals

Arsenic was introduced as an acaricide around 1900. For almost 40 years it was the only product used and resistance did not appear until towards the end of that period. The product was marketed as a liquid concentrate of arsenic trioxide (As_2O_3).

Arsenic had the advantages of being inexpensive, stable and the concentration could be accurately determined and replenished in a simple way. Arsenical compounds cannot be used in a spray race as the mist resulting from spraying contaminates the surroundings and particularly the vegetation with arsenic. Arsenic is very toxic and an extremely irritating and caustic product, especially for the gastrointestinal tract. The safety margin of the prepared ready to use liquid (0.08 to 0.2% depending on whether the intervals between dips are short or long) is very slight (concentrations of 0.24% can already cause skin irritation). Animals brought to the dipping tank over long distances have to be rested and cool down before they can be dipped. Animals dying of acute intoxication may not be consumed. Antidote in case of intoxication: B.A.L 5 mg/kg 4 times a day. The product rapidly degrades in the dips. Moreover, arsenic protects against ticks for not more than 12 hours and its efficacy is lower than that of the modern ixodicides. Because of these drawbacks, the product was replaced with synthetic organic insecticides after World War II.



Arsenic trioxide

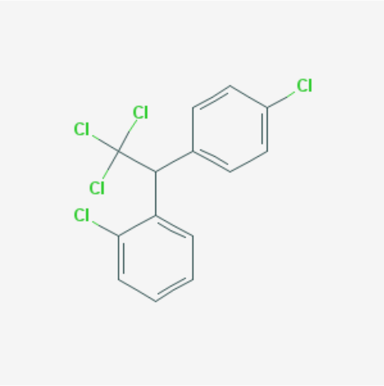
The organochlorinates

These chlorinated hydrocarbons are very stable products and their persistence on the skin and the hide lasts from one to two weeks. In recent years, the use of organochlorinates was banned in most countries because of their polluting (accumulation of these persistent molecules in the food chain) and carcinogenic effects.

Despite the presence of stabilizers in suspensions and emulsions, the active ingredients (especially in plunge dips) rapidly disintegrate. Thus the use of organochlorinates for dipping requires a chemical analysis service in order to check the active agent content in the dipwash. Based on the results the dipwash will be adjusted every 7, 15 or 30 days. Resistance to chlorinated hydrocarbons appeared rapidly: after 18 months for HCH (Hexachlorocyclohexane), 6 years for DDT and 4 years for Toxaphene. It is thought that the rapidly occurring resistance is partly due to the long residual effect of these products. Cross-resistance to all organochlorines has been observed in *R. microplus, R. decoloratus* and *R. appendiculatus*.

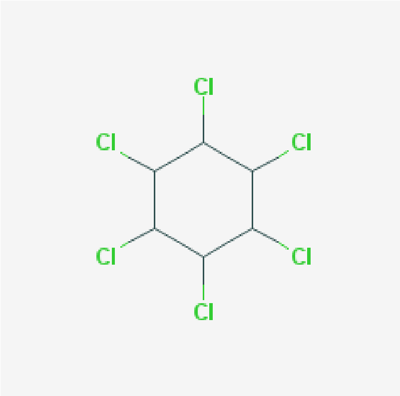
DDT

DDT affects voltage dependent sodium channels. Recognised as dangerous and not very efficient, DDT has fallen into disuse because of its extreme stability and fat solubility leading to bioaccumulation of the product in the environment.



DDT

Gamma-hexachlorocyclohexane or lindane



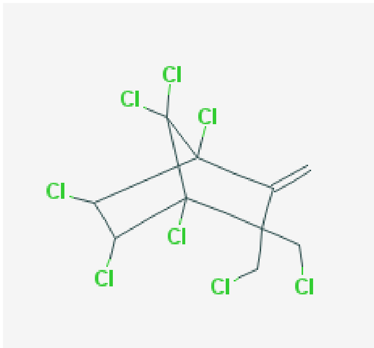
Lindane

Lindane is a chloride channel-blocking insecticide causing hyperexcitability and convulsions. The binding to the chloride channel blocks its activation by gamma-aminobutyric acid. HCH is also a relatively cheap insecticide, but unlike DDT does not present the same risks of product accumulation in the animal. However, its lower stability was responsible for a fairly rapid disintegration of the product in the dipping baths. It was used at a concentration of 300 to 500 ppm.

Toxaphene

Toxaphene is commonly used in Africa and very efficient especially against *Amblyomma* and *Hyalomma* ticks. Very stable in dipping. Residual effect is 4 days for adult ticks, a bit longer for larvae.

Its toxicity for vertebrates is much higher than that of HCH, it is especially dangerous for carnivores. The product is used at a concentration of 0.25 to 0.5%; sometimes it is combined with organophosphates.



Toxaphene

Organophoshorous compounds

The OP presently used for tick control are very efficient and less dangerous as they are quickly metabolised by the homoeotherms and thus do not accumulate.

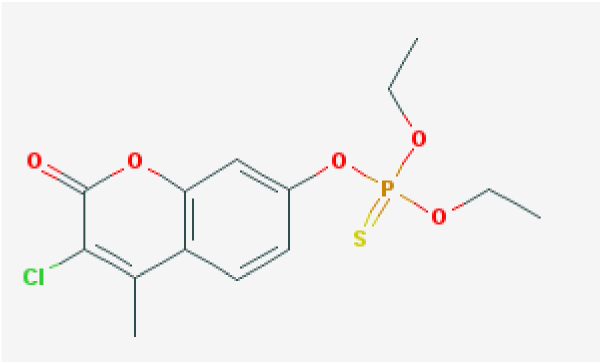
However, different authors noticed that young animals lost weight after treatment.

Antidote in case of intoxication: atropine sulphate (doses possibly to be repeated after 1 or 2 hours: man 2 mg I.M; horse or adult bovine: 10 ml of a solution of 1%; calf, sheep, pig and dog: 2 to 5 ml of a solution of 1%).

Never combine organophosphates for tick control with an organophosphate as anthelmintic (cumulative effect). Resistance to organohosphorous compounds appeared firstly in those areas where *Rhipicephalus* (*Boophilus*) spp. prevailed. First (1963) in Australia and South America (*R. microplus*); and then in 1966 a resistant strain of *R. decoloratus* was found in South Africa. At first sight it was surprising that it occurred at a place where long-interval dips were practised. However, if the animals had been treated once a week, all the larvae (= the stage most susceptible to acaricides) would probably have been killed, even the most resistant ones.

The OPs react with the enzyme acetylcholinesterase. This inactivates the enzyme and blocks the degradation of the neurotransmitter acetylcholine, which is released by the presynaptic cell subsequent to a nerve impulse (depolarisation). Acetylcholine binds to the postsynaptic nicotinic acetylcholine receptor and activates an intrinsic cation channel resulting in a depolarisation of the postsynaptic cell due to the influx of sodium and calcium ions. If acetylcholine is no longer hydrolysed by acetylcholinesterase, the concentration of the neurotransmitter builds up, leading to hyperexcitation of the central nervous system (CNS). Because OPs often require bioactivation and must penetrate into the CNS, the OPs do not have a rapid action like that of the pyrethroids.

Coumaphos (Asuntol, Corral, Agridip Garrapatox)



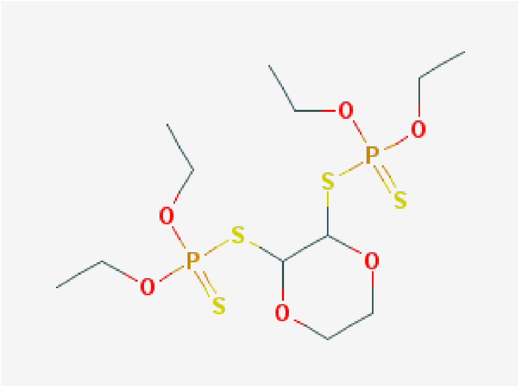
Coumaphos

The product is sold as a 30 to 50% wettable powder or as an emulsion at 16%. The metabolisation of the product is much faster in mammals than it is in arthropods, which means that the product is less toxic in mammals (dl50 rat : 56mg/kg). Calves are not affected by a spray or a dip at 5 times the recommended dose. It is a safe and efficient product but expensive. Asuntol is used for dips and sprays as well as for individual washing. Water with any level of dissolved minerals can be used. The product is rather stable and very efficient (residual effect 4 days). Its disintegration results in the formation of the toxic product potasan. However, by reducing the pH (less than 5.5), it is possible to eliminate the disintegration process without losing efficiency. Should rain fall during the dipping efficacy declines against nymphs and adult ticks.

In case of wettable powders, the recommended dose for dipping and spraying of bovines varies between 0.05% (i.e. 1kg wettable powder at 50% for 1,000 l of water) and 0.125%. A solution of 0.1% is used for sheep. When the water is hard or heavily polluted, the higher concentrations are recommended. In dipping tanks the product remains stable for at least one year. Adding 250 g of copper sulphate per 5000 l water prevents the proliferation of algae. In dips the loss of efficiency is proportional to the amount of dirt brought in by the animals; in such a case asuntol is added at concentrations that are proportional to the level of pollution (0.055 to 0.07%). It is best to have the concentration of the active ingredient in the dip analysed regularly.

As for the 16% concentrated emulsion, 1 ℓ liquid Asuntol is used in 800 ℓ water. To readjust the level of the dipwash, after having treated 200 cattle or after having consumed 500 ℓ of dipwash, 1 ℓ Asuntol is used for 400 ℓ water. The residues in treated animals are low and after a few days, they drop below the detection limit. The milk of treated animals can immediately be consumed.

Dioxathion (Delnav, Bercotox, Tick dip liquid)



Dioxathion

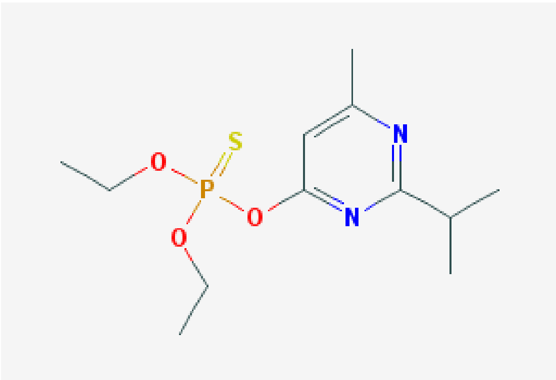
The products developed for dips are concentrated emulsions containing 15 to 30% Delnav. A special formula has been developed for bovines; “Delnav Diluent Free formula” and a mixture of dioxathion 55% and chlorfenvinphos 55% can be used for horses and bovines older than a month (Supramix DFF).

Hand dressing of sheep can be done using grease containing 0.35% dioxathion (tick grease).

The product is stable in water and has quite a long residual effect. It is used at a concentration of 0.05% active agent. When refilling the dip, a quantity of the product slightly higher than the initial one is added (follow the instructions of the manufacturer).

One must wait a week before slaughtering an animal that has been treated with Delnav. It is a product of great value for controlling *R. appendiculatus* in East Africa, especially when applied bi-weekly.

Diazinon (Neocidol, Nucidol, Topclip, Dazzel etc.)



Diazinon

There are concentrated emulsions and wettable powders for dips and sprays on the market with a concentration varying between 25 to 60%. Neocidol 5P (5%) is used for local application. Cats and chickens are very susceptible to Diazinon. The product has low persistence and is much more toxic than Coumaphos. It is used in dosages as follows:

- cattle : dip : 0.03 to 0.06% spray : 0.05 to 0.08%
- small mammals : dip and spray : 0.025 to 0.05%. Lambs younger than six weeks must not be treated!
- dogs and horses : 0.05%

One has to wait one or two weeks before slaughtering an animal that has been treated with Diazinon. The milk cannot be consumed for two days after treatment.

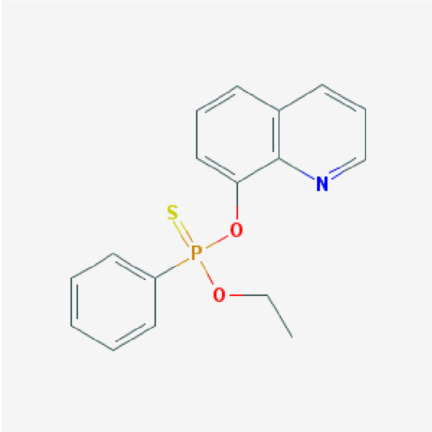
Quinthiophos (Bacdip)

It is a very stable product in a dip, even if the latter is fouled. It can be used for all domestic animals except cats. The product is quite resistant to the tropical heat and thus there are no storage problems.

Bacdip is sold as a concentrated emulsion at 50% (sometimes 30%).

The dosage for dips and sprays for cattle, sheep and goats is as follows 1 l for 2500 l of water (0.02%), for readjustment (replenishment) of the dipping bath or spray reservoir level, one uses 1 l per 1600 l of water (0.03%). Animals cannot be slaughtered for consumption during the seven days following the treatment,.

Dogs can be treated with 10 ml per 10 l of water (0.05%).

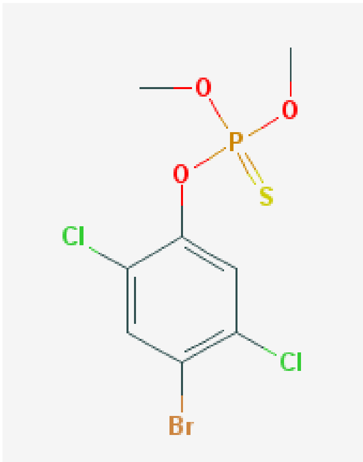


Quinthiophos

Bromophos (Nexion, Tigal etc)

Nexion only contains bromophos, whereas the commercial product Tigal 300 consists of two organophosphates : Bromophos-ethyl 20% and Fenitrothion 10%. These products have little toxicity and leave few residues behind in the body for more than 3 to 4 days after use. The residues in milk do not exceed 0.1 ppm and are rapidly eliminated.

Dosage : Nexion = 0.05%, Tigal 300 = 1 l for 300 to 500 l water.



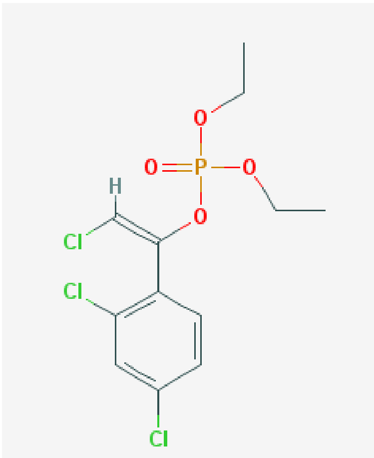
Bromophos

Chlorfenvinphos (Supona) (Supramix DFF =   Supona + Delnav)

Stability is reasonable. The product comes as a 20 to 30% emulsion for dips and sprays. The dosage to use is 0.05%.

Toxicity varies according to the species : for dogs , it is very low when taken orally, but for calves it is quite considerable (20 mg/kg). Given subcutaneously, the product is less dangerous.

Withdrawal period : one week.

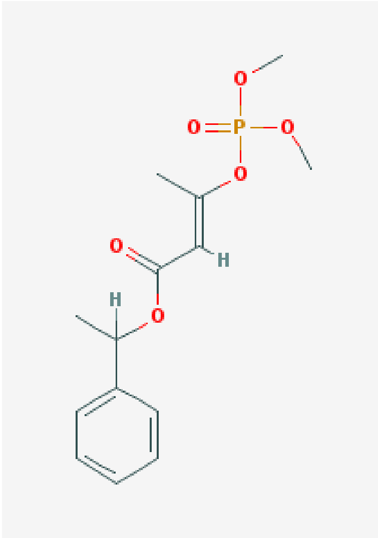


Chlorfenvinphos

Crotoxyphos (Ciodrin)

Ciodrin is sold in emulsion form (24%).

This is an interesting product to control ticks on dairy cows. It leaves no detectable residues (detection limit : 0.001 ppm.) in milk or meat. This means that the animals can be treated with the recommended doses until they are ready for slaughter. The product, which is unstable, should not be used in plunge dips. The spray at 0.15 – 0.3% must be used the very day of its preparation.

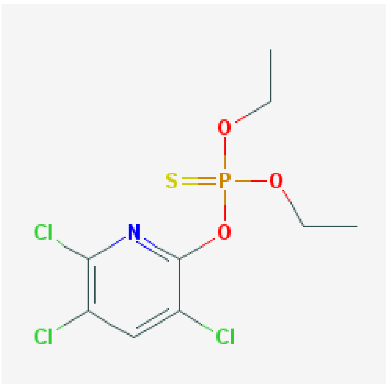


Crotoxyphos

Chlorpyrifos (Killtick Dip, Dursban)

This concentrated emulsion of 10 to 20% is used for individual dipping of sheep and lambs (from the age of 4 days onwards) at a concentration of 0.05%. As soon as the level of the dip drops by 25%, it has to be refilled with an emulsion at 0.075%.

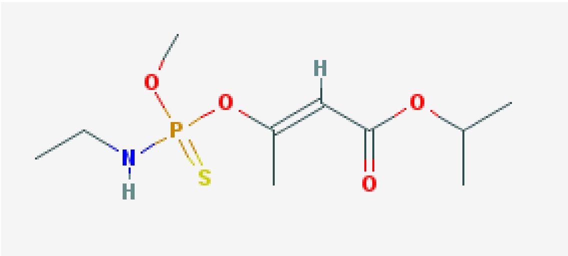
The product is not very stable.



Chlorpyrifos

Propetamphos (Blotic, Bostan, Young's Summer Dip)

These products contain 8 to 35% active ingredient and they are used for both dip and spray at a concentration of 0.03 to 0.035%. For manual spraying and readjustment of the dip, the concentration of 0.05% is used. Lambs under the age of 3 months are not to be treated with this product. Hard water must be softened before use with 1kg soda per 500 l water. The dipwash can only be used for one week. Withdrawal period: 2 weeks for meat, 60 h for milk.



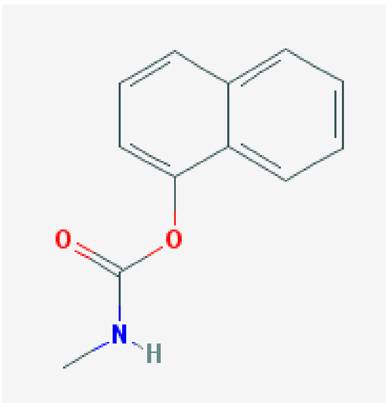
Propetamphos

The carbamates

Their mode of action is similar to that of the OPs.

Carbaryl-based wettable powders have been used as a spray at a concentration of 0.1% or 0.15% (Promecarb).

Carbaryl has been used for spraying infested pastures at a dose of 1kg/4 km2.



Carbaryl

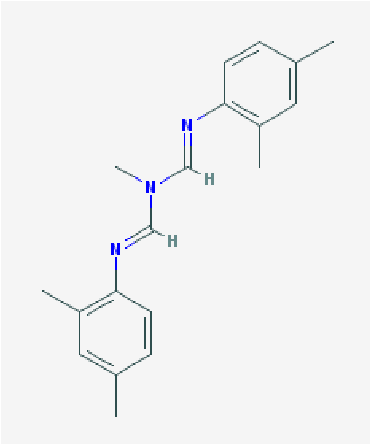
The amidines

These compounds mimic the action of the neurotransmitter octopamine, which regulates behavioural arousal within the CNS. Octopamine binds to a receptor that elevates levels of the second messenger, cyclic adenosine monophosphate (AMP). Cyclic AMP then initiates processes that give rise to neuronal excitation. Amidines cause an overstimulation of octopaminergic synapses in insects, resulting in tremors, convulsions, and continuous flight behaviour in adult insects. Moreover, they cause anorexia and suppress reproduction in arthropods.

Amidines were developed to control ticks that had developed resistance to organophosphates.

Amitraz (Taktic, Azaform, triatox)

This noncyclic amidine is presented as a wettable powder (WP) at 23.75 and 50% and as a concentrated emulsion (CE) at 12.5 and 23.75%. The concentration used for spraying is 0.025% (CE) and for dipping 0.025 (WP) and 0.05% (CE). The product becomes unstable when the pH drops (urine, faeces, and microbes). Before, it was necessary to add an alkaline stabiliser e.g. Ca (OH)2 at a concentration of 0.5-0.7% that would maintain the pH between 10 and 12 (1.25% for the refills). Today there are new formulations, which do not require any stabiliser.



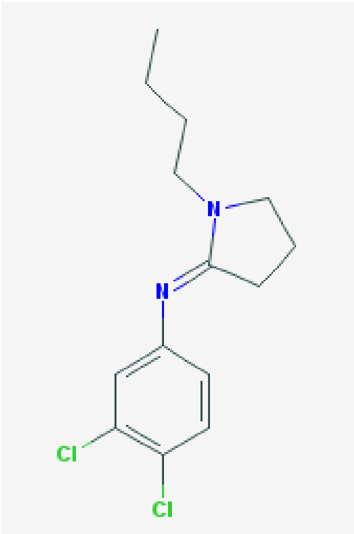
Amitraz

Amitraz causes the ticks to detach rapidly (within 30 min to 8 h). They also lose the ability to cling to another host. Amitraz has ovacide activity, a long-term persistence and is relatively cheap.

Withdrawal period: one week. Amitraz is very toxic to horses and may not be used on these animals!! Sometimes young animals lose weight after treatment.

Clenpyrin (Bimarit)

This amidine causes fast-progressing muscular paralysis in ticks and prevents maturation of the eggs in females. The product has a repellent effect on ticks and since it is stable in dips, no stabiliser is needed. After treatment Clenpyren builds up in the fatty tissues, but after two weeks this level will have dropped 10 times.



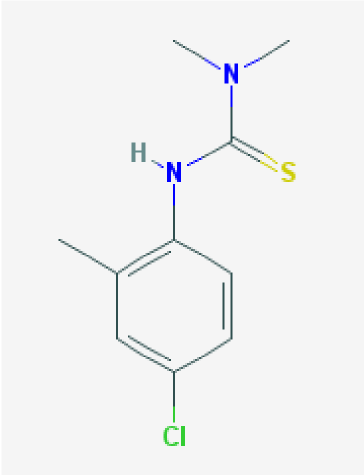
Clenpyrin

The Thioureas

The mode of action is similar to that of the formamidines but they are more stable in the dipping tank.

Chloromethioron (Dipofène 60)

Put on the market as a flowable consisting of a 60% suspension of extra fine particles in a watery environment (puddinglike consistency). The product is very stable in a dipping tank and doesn't require a stabilizer. Even a dip that has been out of use for a while retains its product content. The stripping phenomenon doesn't take place but flowables have the tendency to come out of suspension and settle to the bottom of the tank if they are not constantly agitated. The product has little toxicity for mammals and is active on resistant strains. The duration of effectiveness is 7 days. Residues in animals do not exceed 0.15 ppm in meat and 0.17 ppm in milk. The product is used at a concentration of 0.18%.



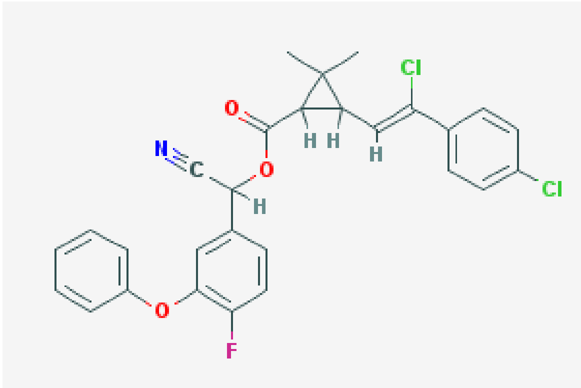
Chloromethioron

Long-lasting pyrethroids

Pyrethroids prolong the flow of the current flowing through sodium channels by slowing or preventing the closure of these channels. This has a potent effect on nerve impulse generation within both the central and peripheral nervous systems. Under normal conditions, neurons possess a negative transmembrane voltage of about –60 mV on the inside. The nerve impulse or action potential consists of a transient depolarisation (positive wave) whose upstroke is driven by an influx of sodium ions, followed by a downstroke from the efflux of potassium ions. The action potential is propagated down the axon until it reaches the nerve terminal, where it stimulates the release of chemical transmitters. The duration of modified sodium currents by type 1 compounds last tens of milliseconds, while those of type 2 pyrethroids last for minutes or longer. Long-lasting pyrethroids arevery efficient against ticks resistant to organophosphates, but in Australia and South Africa cross resistance (Knock Down Resistance - kdr) was observed in *Rhipicephalus* (*Boophilus)* ticks resistant to DDT.

A disadvantage of these products is their rather high price and the fast-developing resistance (especially against permethrin). In some countries combination products of pyrethroids and organophosphates are available on the market, since a synergistic effect was observed of organophosphates on pyrethroid-resistant ticks.

Flumethrin (Bayticol)



Flumethrin

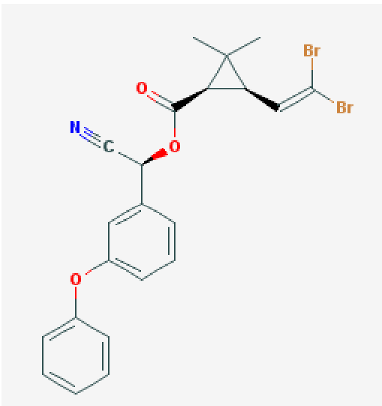
A residual effect of 7 to 9 days against one-host ticks is shown by the effect on the larvae. The effect on two- or three-host ticks will first show in the larvae and the nymphs and next in the adults, which will be killed after a contact of 1 to 8 hours. There is a strong reduction of the number of viable eggs produced by the female ticks that have been in contact with the product, but have not received a lethal dose. The product is on the market as an emulsifiable concentrate at 2.6% or 7.5%. The product is very stable in dips (no stripping) and can be used on animals of any age. The concentration is 0.004% (40 ppm) for a plunge dip and 0.005% for a spray.

A pour-on formula at 1% used at 1 mg/kg also exists, which is very efficient (100% of *R. appendiculatus* controlled during the first six days after treatment).

The product does not leave any detectable residues in the tissues of the animals, neither is there significant secretion through the milk. However, weight loss was observed in young animals.

Deltamethrin (Decatix)

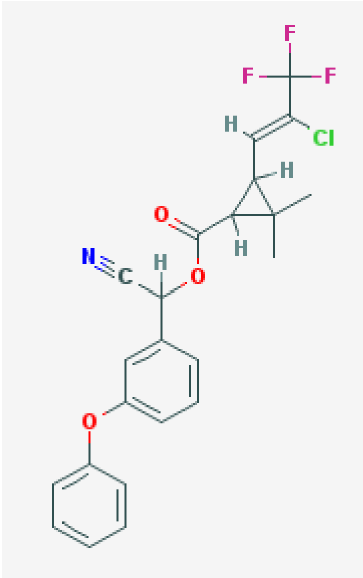
There are concentrated solutions of deltamethrin available for use in dips and sprays. The concentration used in a dipping tank lies between 0.0025% (25 ppm) and 0.0038% (0.45% for refilling). For spraying, a solution of 0.005% is used. The persistence of the product is long: 15 days in the dry season, 7 days in the rainy season, but the product is not 100% efficacious in eliminating all ticks. Moreover, tick resistance has been detected. Treatment also has a lethal effect on tsetse flies feeding on treated animals,



Deltamethrin

Lambda-cyhalothrine

This is especially efficient in a spray at a dose of 0.005 to 0.01%.

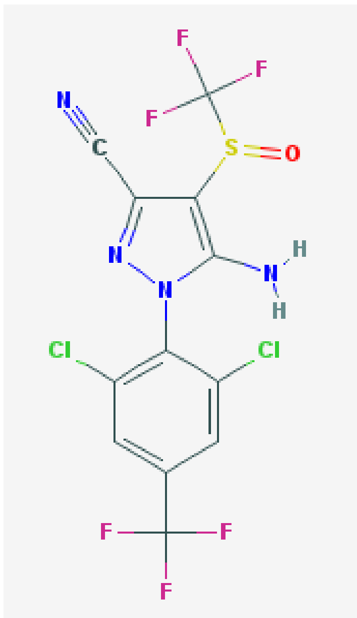


Lambda-cyhalothrine

Phenylpyrazole compounds

Fipronyl

Available as a pour-on formulation for control of ticks in several Latin American countries. Good therapeutic efficacy against *R. microplus* but the product is not very stable under field conditions. The product has an effect on oocyte development and causes salivary gland degeneration.

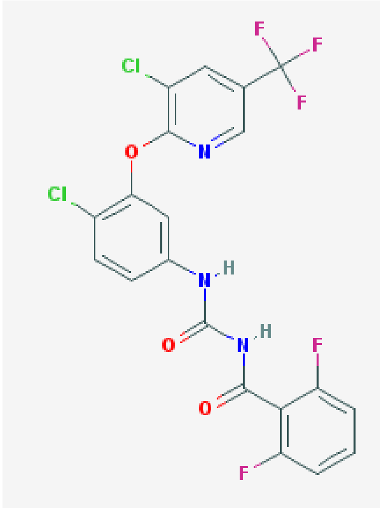


Fipronyl

Benzoyl phenyl ureas

Fluazuron

This chitin synthesis inhibitor is efficacious against *Rhipicephalus* (*Boophilus*) ticks. The pour-on formulation does not prevent the tick feeding but during a period of almost 12 weeks reduces the fecundity and fertility of engorged females to close to zero and causes significant mortality among immature ticks because they are unable to moult to the next instar. Because of its binding to fat, fluazuron is excreted in milk and it is thus unnecessary to treat calves suckling on treated cows. Long withholding time: six weeks after treatment.

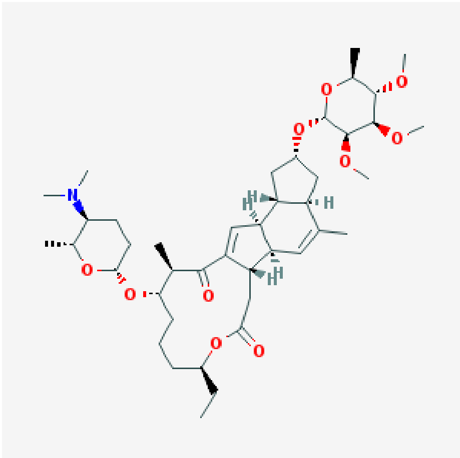


Fluazuron

Spynosins

Spinosad

Spinosad is a fermentation metabolite of an actinomycete and disrupts the binding of acetylcholine in postsynaptic nicotinic acetylcholine receptors. It has persistent efficacy against larval reinfestations with *R. microplus* for two weeks after treatment. Efficacy is greater against nymphal and larval ticks than against adults.



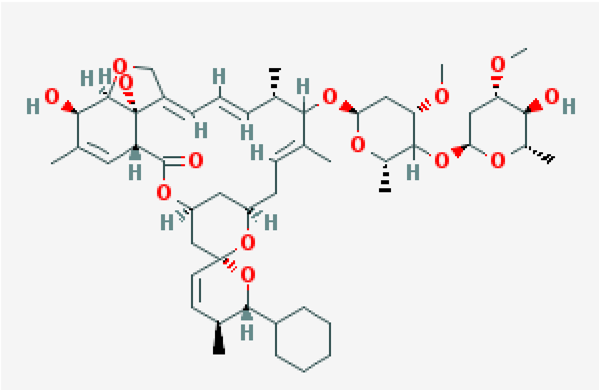
Spinosad

Synergists

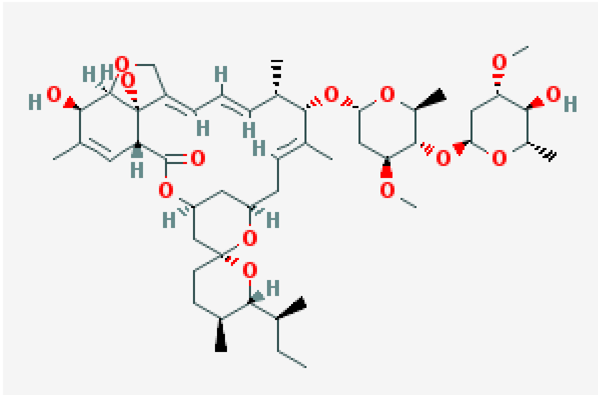
These compounds are not in themselves toxic or insecticidal, but used with insecticides, enhance their activity. They are used extensively in household sprays (aerosols) containing pyrethrin, and are also used in some (but not all) organophosphates, organochlorines, carbamates as well as some plant-derived insecticides. Their mode of action is their binding to oxidative enzymes that would otherwise degrade the insecticide. Examples are: Sesamex, piperonyl butoxide, sulfoxide and MGK 264.

Macrocyclic Lactones

The macrocyclic lactones (avermectins and milbemycins) are products, or chemical derivatives thereof, of soil microorganisms belonging to the genus *Streptomyces*. The avermectins in commercial use are ivermectin, abamectin, doramectin, eprinomectin, and selamectin. Commercially available milbemycins are milbemycin oxime and moxidectin. The macrocyclic lactones have a potent, broad antiparasitic spectrum at low dose levels. They are active against many immature nematodes (including hypobiotic larvae) and arthropods. The published literature contains reports of use to treat infections of >300 species of endo- and ectoparasites in a wide range of hosts. Moreover, a single therapeutic dose can persist in concentrations sufficient to be effective against incumbent nematode infections for prolonged periods after treatment.



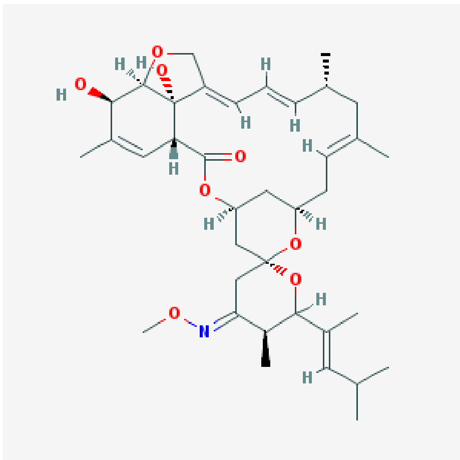
Doramectin



Ivermectin

The macrocyclic lactones are well absorbed when administered per os (PO), parenterally, or as pour-on formulations. Regardless of the route of administration, macrocyclic lactones are extensively distributed throughout the body and concentrate particularly in adipose tissue. However, the route of administration and formulation may affect disposition. The residence time of macrocyclic lactones administered subcutaneously (SC) may also be influenced by the body condition of the animal.

Examples: Ivermectin, Doramectin, Moxidectin



Moxidectin

ADDITIONAL READING

1. Acaricide resistance: diagnosis, management and prevention (FAO, 2004) (Guidelines resistance management.pdf) ftp://ftp.fao.org/docrep/fao/010/ag014e/ag014e05.pdf.
2. Effect of red-billed oxpecker on tick load (Oxpecker.pdf). http://beheco.oxfordjournals.org/content/11/2/154.full.
3. Endemic stability (Stevens et al_2007.pdf; Rikhotso et al_2005.pdf; Endemic stability.pdf)
4. Foot baths to control *Amblyomma* ticks (Foot batch.pdf)
5. *Amblyomma* attachment kinetics (Amblyomma_attachment.pdf)
6. Jonsson, N. N. & Piper, E.K., 2007. Integrated control programs for ticks on cattle. School of Veterinary Science, The University of Queensland, Australia.

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8. Stevens et al., (2007). Influence of dipping practices on the seroprevalence of babesiosis and anaplasmosis in the foot-and-mouth disease buffer zone adjoining the Kruger National Park in South Africa. *Onderstepoort J Vet Res* 74(2), 87-95.
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10. Payne, W. J. A., 1964. The origin of domestic cattle in Africa. Empire J. Exp. Agric. 32 (126), 97-113.
11. Weeks, P. (2000). Red-billed oxpeckers: vampires or tickbirds? *Behavioural Ecology* 11(2), 154-160.