An introduction to the biology and control of ticks in Africa

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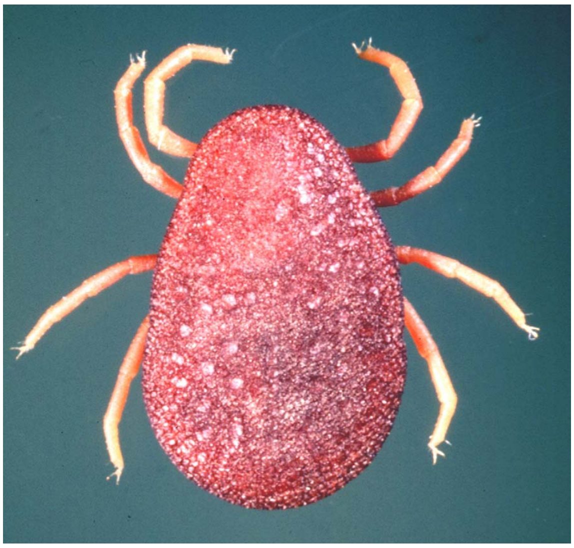
Contents

Ticks in relation to other animals.

Ticks are closely related to animals such as spiders and insects. These are all animals without a spine (= invertebrates). They belong to a group called the phylum Arthropoda. The ticks are within a group called the order Acari. This consists mostly of mites, including mites which are parasitic on mammals and birds. Ticks are very similar to mites but are larger and all of them only feed as parasites. In the world there are 866 species of tick that have been described.

***Amblyomma variegatum*, female dorsal view.** This is a typical ixodid or hard tick. It has four pairs of powerful legs for active running. Mouthparts protrude in front of the body.



***Argas persicus*, female dorsal view.** This is a typical argasid or soft tick. It has four pairs of legs for crawling. Mouthparts are located on the under-side of the tick.

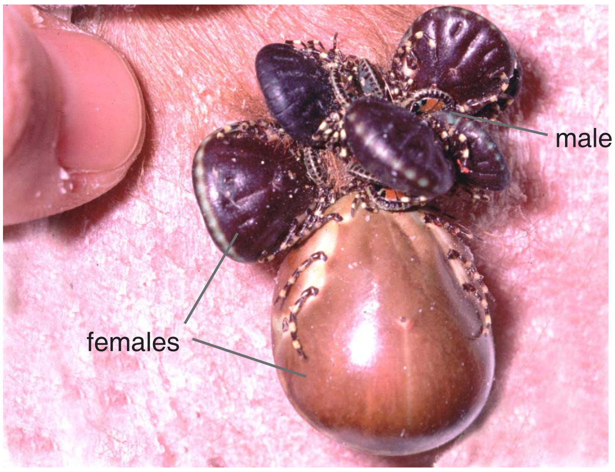
There are two main groups of ticks called the family Argasidae or argasids, and the family Ixodidae or ixodids. Argasid ticks are often called soft ticks because they do not have hard plates on their bodies. The ixodids are often called hard ticks because they have these hard plates.

Arthropoda (a phylum) = ticks, mites, spiders, insects, crustaceans and others
- Arachnida (a class) = ticks, mites, spiders, scorpions and others
  - Acari (an order) = ticks and mites
    - Ixodida (a sub-order) = ticks
      - Argasidae (a family) = soft ticks
        - *Argas* (a genus, one of five)
          - *Argas persicus* (a species)
      - Ixodidae (a family) = hard ticks
        - *Amblyomma* (a genus, one of 14)
          - *Amblyommma variegatum* (a species)

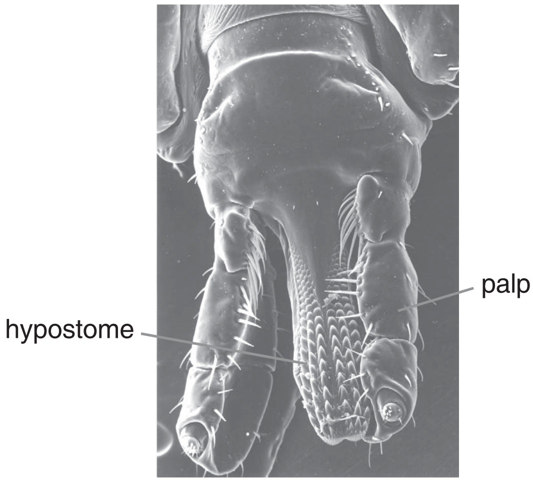
Tick feeding.

Importance of tick feeding to animal health.

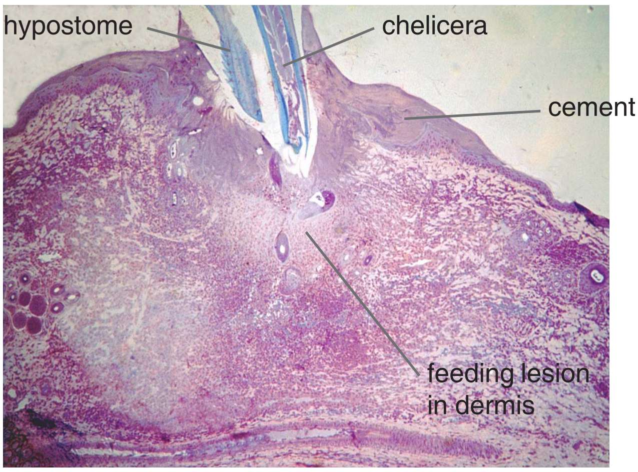
It is the feeding of ticks that makes them important in the health of domestic animals and humans. During feeding ticks cause disease to their hosts by taking blood, injuring the skin, causing irritation and pain, and sometimes by causing poisoning. More serious disease is often caused when the ticks are infected with microorganisms. These are transmitted to humans or domestic animal when the ticks feed and may cause weakening or fatal disease in the host. This type of microorganism is known as a pathogen and when a tick transmits it the tick is known as a vector of the pathogenic microorganism.



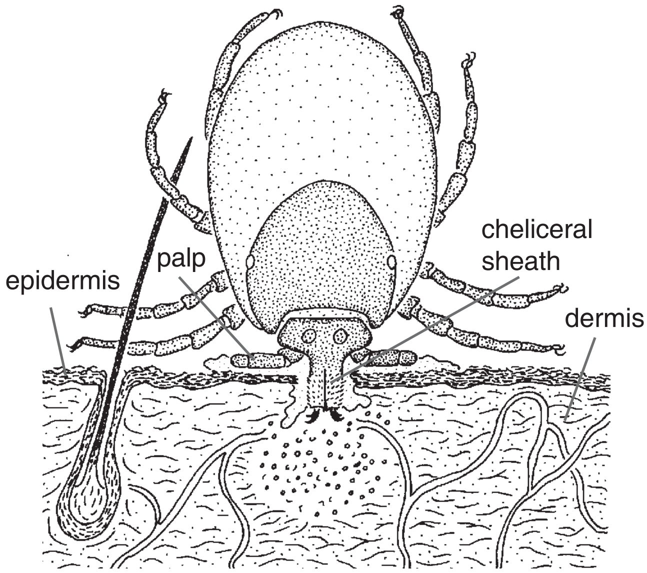
***Amblyomma variegatum* feeding.** A typical aggregation of females and males.



***Hyalomma anatolicum* mouthparts, ventral view.**



***Rhipicephalus appendiculatus* feeding site in skin of cow.**



Generalized tick feeding site.

All feedings of ticks at each stage of their life cycle are parasitic. Ticks feed only on the blood of their hosts. The ticks crawl onto their host and attach to the skin. They use a combination of cutting mouthparts which penetrate the skin and often an adhesive (= cement) is secreted in the saliva to aid attachment to the skin. At the end of the mouthparts are sharp chelicerae that scrape a hole into the dermis. This breaks the capillary blood vessels very close to the surface of the skin and the tick feeds on released blood. On the ventral surface of the mouthparts is the hypostome which is barbed with teeth to grip the host. A feeding tube into the tick is formed between the hypostome and the sheath surrounding the chelicerae.

The feeding of ixodid ticks is slow because the body wall needs to grow before it can expand to take a very large blood meal. Larvae take 3 to 5 days to fully engorge with blood, nymphs 4 to 8 days, and females 5 to 20 days. When the ticks have engorged with blood they detach from the host's skin and drop to the ground. Males of most types of ticks feed but do not expand like the females. They feed enough for their reproductive organs to mature. Male ticks in the genus *Ixodes* have active reproductive organs as soon as they moult from the nymphal stage and do not need to feed.

The argasid ticks usually feed more rapidly, in minutes to several hours. They only take small blood meals but take many of them in each stage of the life cycle. They do not have the complex attachment to the skin that ixodid ticks have.

Host finding

All ticks spend most of their life cycle away from their hosts, hiding either in soil and vegetation or in the nests of their hosts. So they need to be able to find hosts on which to feed. Ticks do this in several ways. Many ticks have the eggs and moulting stages in soil or vegetation in the environment in which their hosts graze or hunt. The ticks crawl onto vegetation and wait for their hosts to pass by. This is a type of ambush and the behaviour of waiting on vegetation is called questing. Thus in the group of ixodid ticks such as *Rhipicephalus* the larvae, nymphs and adults will quest on vegetation. The ticks grab onto the hosts using their front legs and then crawl over the skin to find a suitable place to attach and feed.

Questing larvae of *Rhipicephalus appendiculatus*. The larvae cluster to conserve moisture. They are high on a grass stem for best contact with hosts and become active as soon as they sense a host approaching.

Questing female of *Ixodes ricinus*. This tick is activated by sensing a host and holds its front legs out for sensing the host and grasping onto the host with paired claws on each leg. The downward facing posture is typical.

Adult ticks of the genera *Amblyomma* and *Hyalomma* are active hunters and will run across the ground to seek hosts that are resting nearby. Other ticks, such as nearly all argasid ticks, and many *Ixodes* species, spend their life cycle in or near the nests or shelters of their hosts (= endophilic or nidicolous behaviour). Some ticks are adapted to living in the housing of domestic animals. Attractants released by hosts that stimulate questing by ticks include carbon dioxide and ammonia.

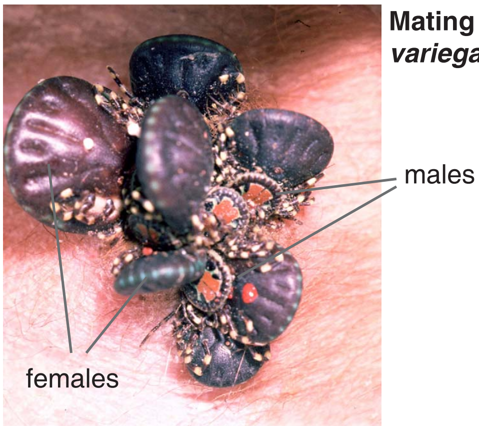
Questing *Amblyomma variegatum* male (top) and female (bottom). *Amblyomma* adults hunt for their hosts over short distances by running to them over the ground.

Questing *Hyalomma anatolicum* female. This is on a mass of cobwebs on the housing of its host and will actively crawl from its resting site to its host. The front legs are held out to sense and grasp the host.

Tick reproduction and life cycles.

Mating.

In the hard ticks mating takes place on the host, except with *Ixodes* where it may also occur when the ticks are still on the vegetation. Male ticks remain on the host and will attempt to mate with many females between repeated feedings. They transfer a sac of sperm (= spermatheca) to the female. The females mate only once, before they are ready to engorge fully with blood. When they finally engorge they detach from the host and have enough sperm stored to fertilize all their eggs. Female hard ticks lay many eggs (2000 to 20,000) in a single batch. Female argasid ticks lay repeated small batches of eggs. Eggs of all ticks are laid in the physical environment, never on the host.

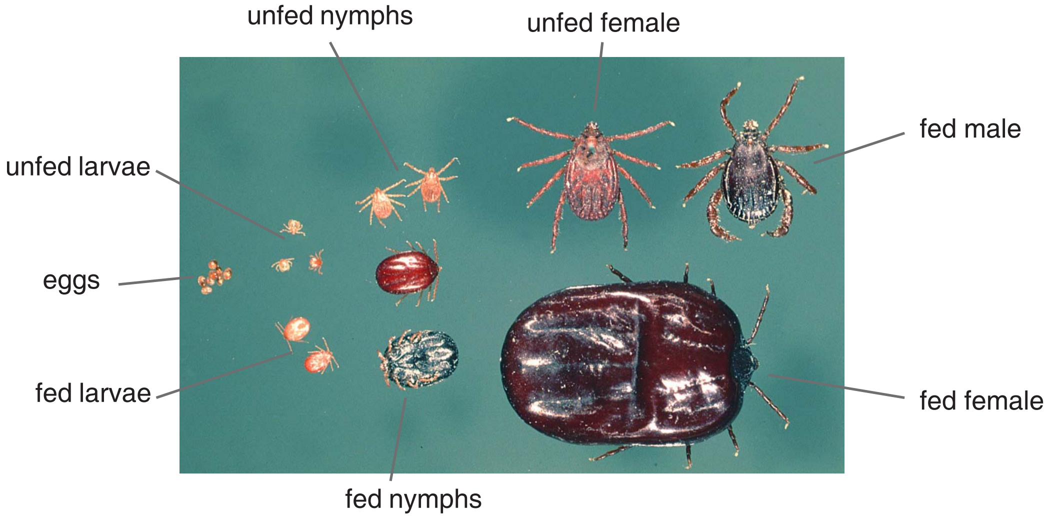


Mating *Amblyomma variegatum* on their host.

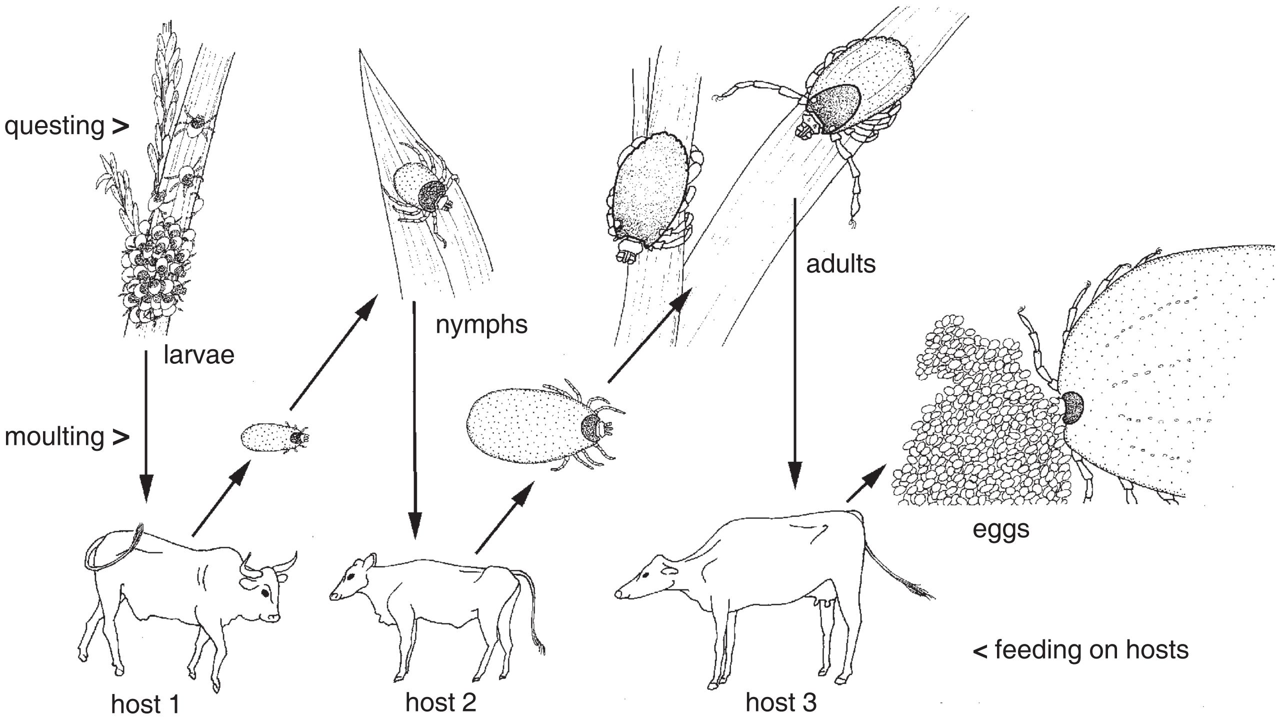
Egg laying in *Amblyomma variegatum*. The female at the right has laid about 20,000 eggs and will die. The female in the centre is fully engorged and about to start ovipositing. For comparison a fed male is shown at far left.

Life cycle of three-host ticks.

The illustrations on page 6 show the sequence of feeding and moulting during the life of individual ticks from a single batch of eggs of a typical three-host species. This is the commonest type of life cycle. Larvae develop in the eggs until ready to hatch, usually in several weeks. Larvae feed once on a host, then detach from the host and hide in the physical environment such as soil or vegetation. They moult to nymphs. Nymphs feed once and moult in the same way as larvae. From the nymphal moult either a female or male emerges. The female feeds once and lays one huge batch of eggs. She then dies. The males may take several small feeds, mate and then die. Ticks that have recently hatched from eggs or from moulting have soft bodies and are inactive for one to two weeks whilst the external body wall hardens. The life cycle of three-host ticks is slow, from 6 months to several years to complete.



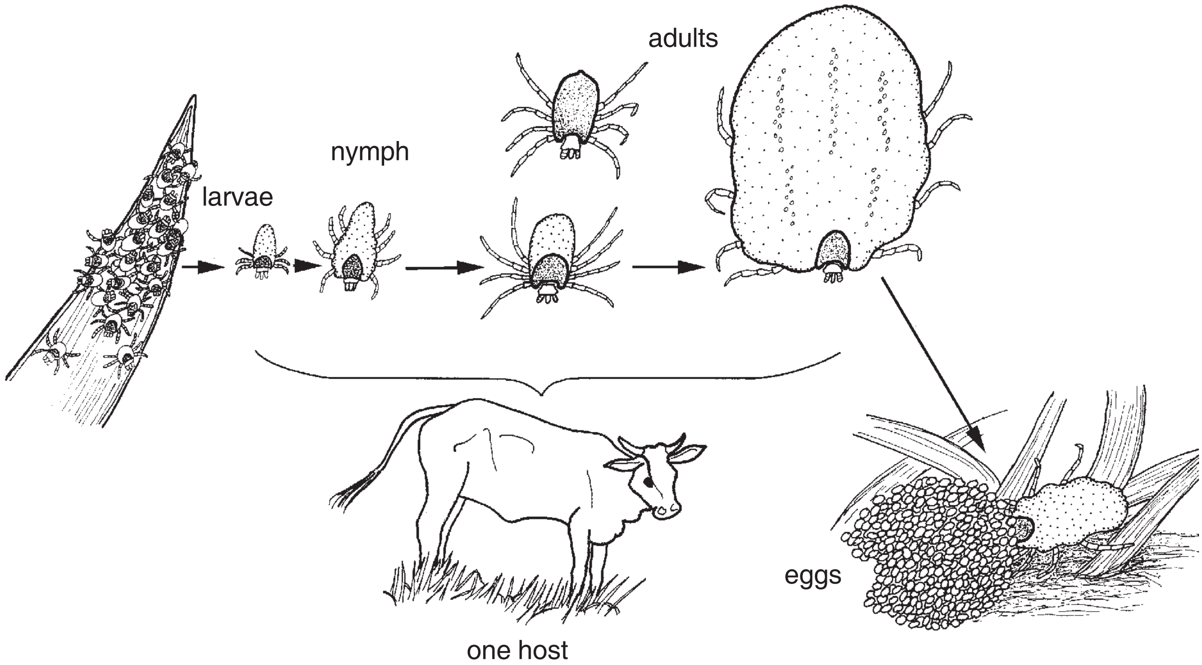
Stages of the life cycle of an ixodid tick (*Rhipicephalus appendiculatus*).



A three-host feeding sequence of an ixodid tick (*Rhipicephalus appendiculatus*).

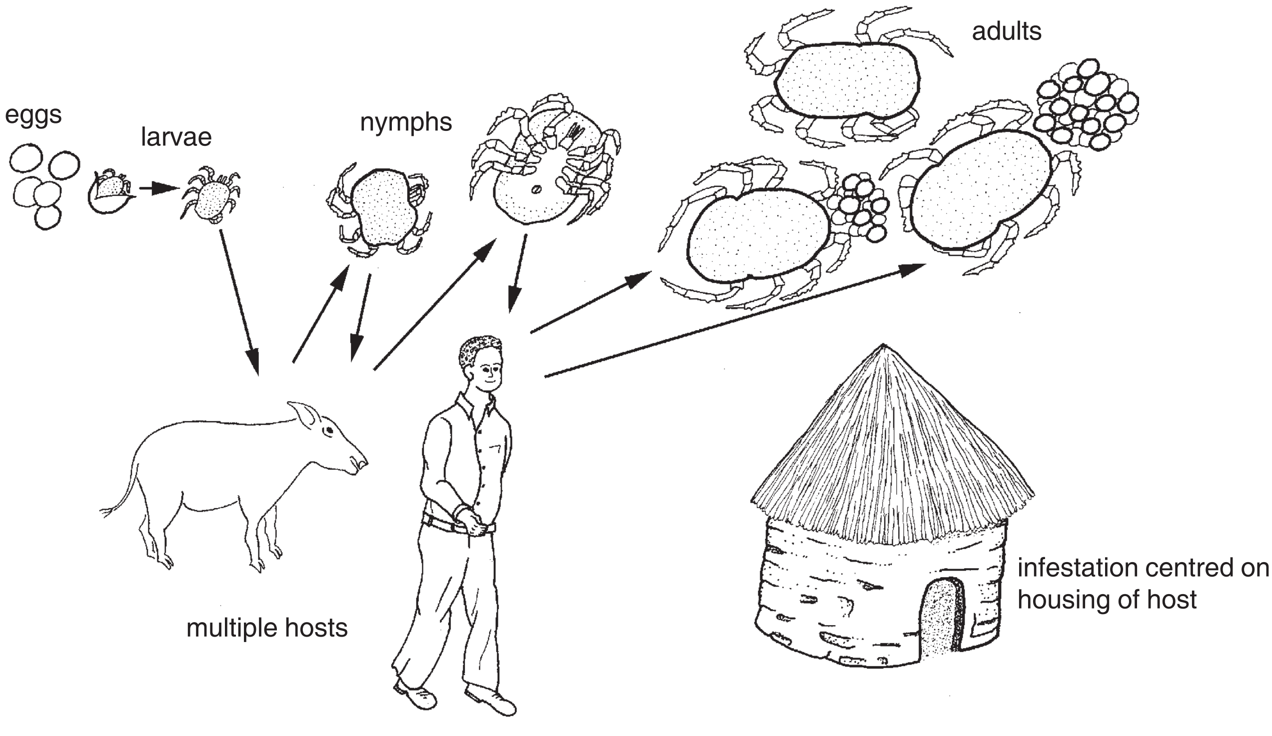
Life cycle of one and two-host ticks.

The illustration on page 7 shows the sequence of feeding and moulting during the life of individual ticks from a single batch of eggs of a typical one-host species. This is a less common type of life cycle but it occurs in all species of *Boophilus* sub-genus (which are now classified within the genus *Rhipicephalus*). The two-host life cycle is similar but only the larvae and nymphs feed on the same individual host, and the adults will feed on another host. Eggs are laid in the physical environment. Larvae develop in the eggs until ready to hatch, usually in several weeks. When they have completed feeding they remain attached to the host and moulting occurs there. The nymphs then feed on the same host and also remain attached. After another moult the adults hatch then feed on the same host. The adults will change position on the same host for mating. Thus all three feedings of any individual tick occur on the same individual host. The life cycle of one-host ticks is usually rapid, for boophilid species it takes three weeks for the feedings on one host and two months for egg laying and hatching of larvae.



A one-host feeding sequence of an ixodid tick (a boophilid species).

Life cycle of argasid ticks.
The illustration shows the sequence of feeding and moulting during the life of individual ticks from a single batch of eggs of a typical argasid species. Most argasids are multi-host ticks, but *Otobius megnini* has a one-host life cycle. Larvae either feed rapidly, or during several days in many species, then detach from their host and moult. In some argasids the larvae do not feed, they moult directly to the first nymphal stage. The first nymphal stage feeds rapidly then moults to a further nymphal stage. Similar feedings follow on different individual hosts and there are often a variable number of nymphal stages. When adults develop the females feed rapidly on an individual host then produce a small batch of eggs (100 to 500). The females repeatedly feed then lay eggs, up to six feedings and egg layings. Mating occurs off the hosts.



A feeding sequence of an argasid tick (*Ornithodoros moubata* group).

Tick ecology.

Habitats.

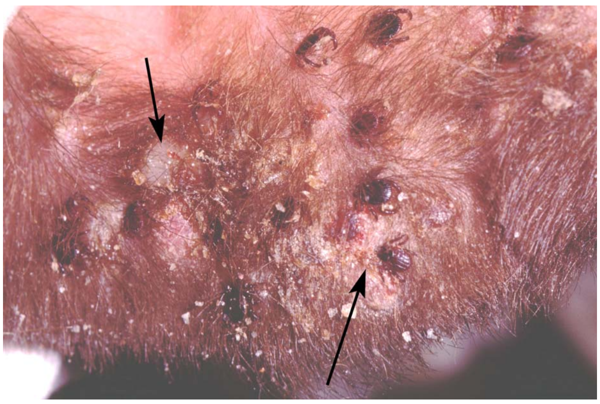
A tick's habitat is composed of the variety of living and non-living things in the space in which it lives. Ticks are adapted to two contrasting components of their habitat: the physical environment and their host. When ticks are moulting and then questing in the physical habitat they are in danger of drying out and starving. The larvae are most susceptible because of they have a high surface area relative to their small volume. They are also exposed to predators such as rodents, birds, reptiles and ants, and to pathogens such as fungi. These adverse factors limit the type of habitats that a species will be found in and knowledge of the typical physical habitat of a species is an aid in identification. The most important component of the physical habitat of a tick is the climate that is defined by temperature and humidity.

Cattle pasture in highveld of Zimbabwe. Sufficient rain for long grass, good habitat for *Rh. appendiculatus*, *Rh. decoloratus* & *Am. variegatum*.

Sheep grazing in coastal plain of Morocco. Dry climate to which *Hyalomma* species are adapted, often as domestic infestations.

When the same tick is on the host it is no longer in danger of drying out or starving, but is in danger of being removed by the host's grooming or having its feeding reduced by host immunity. Most ticks have adaptations in their behaviour and physiology of feeding to reduce these host reactions. Usually these adaptations work best for a certain type of host. However the distribution of the potential hosts of a species of tick may often be much larger than the distribution of the tick. Ticks feeding on their hosts may also be eaten by domestic chickens and oxpecker birds.

***Rhipicephalus appendiculatus* adults feeding on a naive (non-resistant) calf's ear.** Females have mated and are engorging.



***Rhipicephalus appendiculatus* adults feeding on the same calf after it had acquired resistance.** Arrows show inflammatory reactions at feeding sites. Females are failing to engorge.

Hosts.

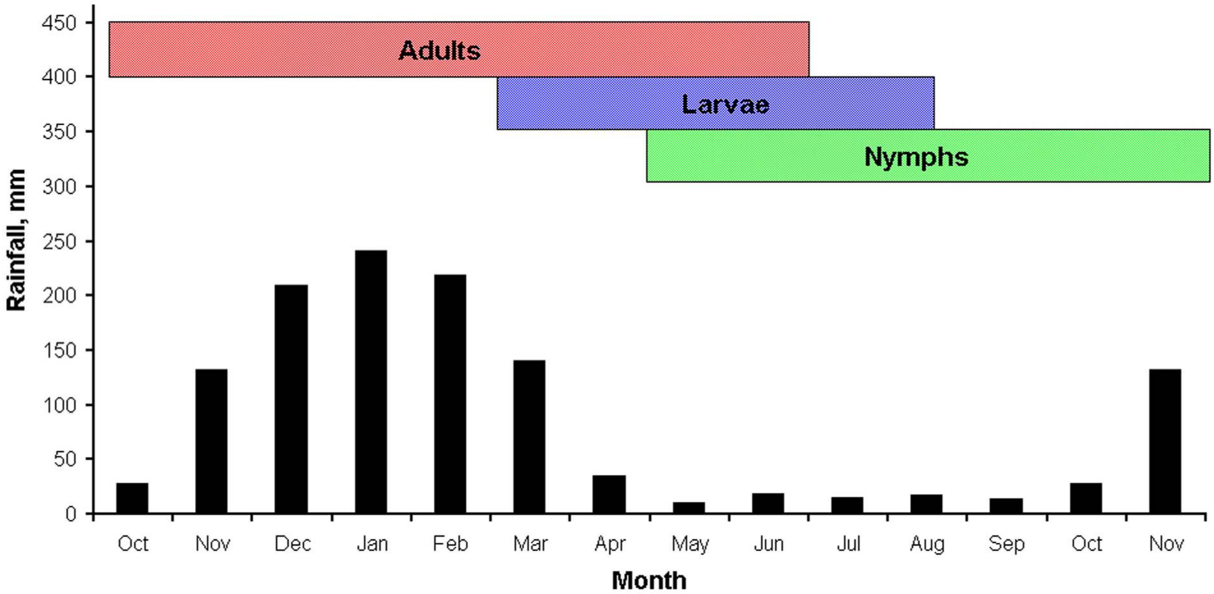
Most ticks have characteristic species of hosts to which they are adapted. These hosts may be a single species but more commonly are a group of similar species. For example all the boophilid species are highly adapted to feed on cattle, but some species may survive by feeding on sheep. Because boophilids are one-host ticks all stages must be able to feed properly on the same species of host. Compare this with *Rhipicephalus appendiculatus* that is found most commonly on cattle. All stages feed well on cattle and similar hosts in the family Bovidae such as sheep and goats and many wild species such as buffalo and eland. They are also found attached to a very wide range of hosts in other families, from primates including humans, to dogs, lions, zebra, and hares.

The survival of a population of ticks depends on the presence of hosts suitable for reproduction by the adults. These hosts are known as maintenance hosts. These hosts are more limited in variety than the hosts on which larvae and nymphs of three-host ticks can survive. They are also more limited than those on which adults may attempt to feed but not necessarily survive. To use information of tick hosts for identification it is important to realize that a species of tick has a characteristic range of host species but may be found much less commonly on many other kinds of host species. For example, carnivorous mammals may be infested temporarily with ticks which have transferred from their herbivorous prey.

Cape buffalo. A common wild host for *Rhipicephalus appendiculatus* that can maintain the tick's population.

Lion. A predator that has been recorded as a host for *Rhipicephalus appendiculatus* but is unlikely to maintain the tick's population.

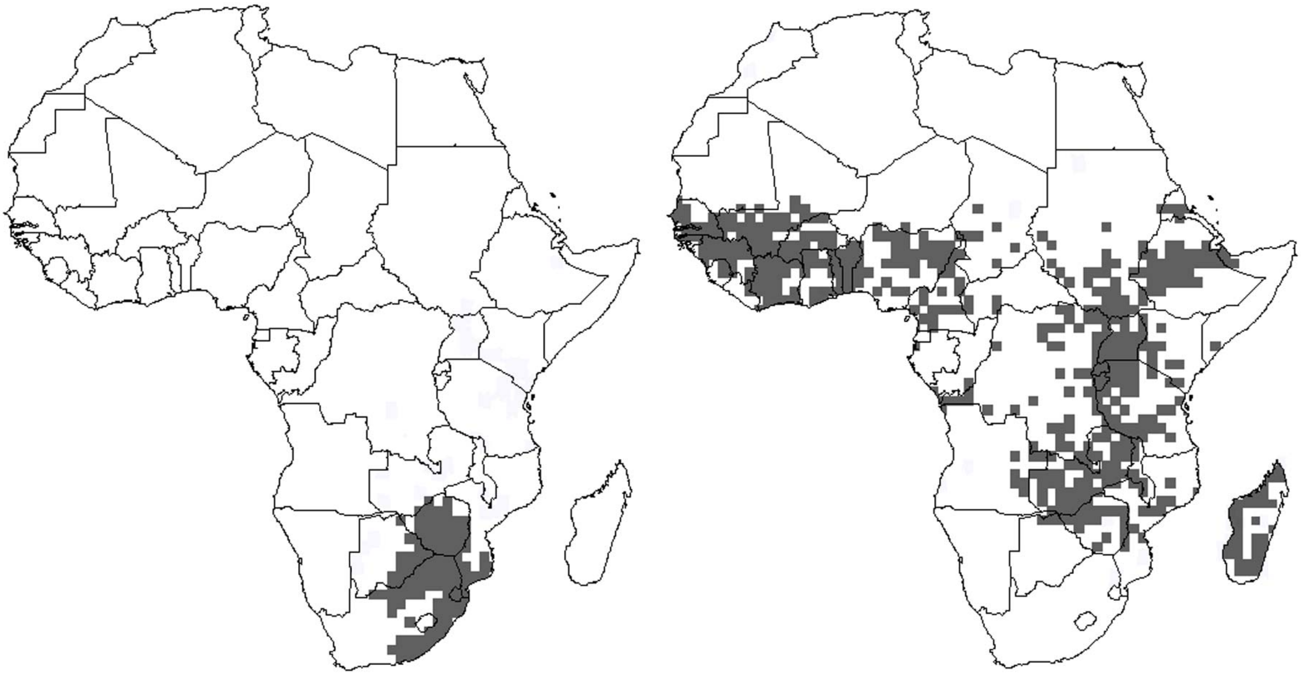
Seasonal occurrence.
The activity of many species of tick is adapted to seasonal variations in climate. In the tropics this is usually to overcome the adverse effects of a long dry season. The survival of many species is improved if they have a seasonal cycle which reduces these risks. For example *Rh. appendiculatus* in southern Africa has mechanisms, known as diapause, that delay the questing of adults so that their feeding and reproduction starts at the beginning of the single rainy season. This is followed by peak numbers of larvae toward the end of the rainy season when humidity is highest. Knowledge of the time of year when adults of a species are likely to be found on their hosts is thus an aid to identification.



Rainfall and seasonal feeding activity of *Rh. appendiculatus* in southern Africa (based on several sources). There is a single generation of ticks each year, with timing of activity controlled by diapause.

Geographical distribution.

For some species of ticks there are many published records of the geographical sites in which they have been found. These records can be converted into maps which give a general indication of where a species is likely to be found because of where it has been found before. If a species has only ever been recorded north of the Sahara then it is unlikely to be found to the south. However this important aid in identification has several complications. For example the type of habitat in which the species is found is likely to be much more widely distributed than the current geographical range of the tick. Thus a tick found in a similar habitat but a far away geographical area from its usual distribution could have become imported recently. Also these maps depend on data from tick surveys which vary in their extent from country to country, so gaps in distribution on a map may mean that nobody has looked for them there.



Distribution of *Amblyomma hebraeum* (left) and *Amblyomma variegatum* (right). Only in Zimbabwe do these species occur in the same areas. This is important in the epidemiology of cowdriosis and assists in identification of these similar ticks.

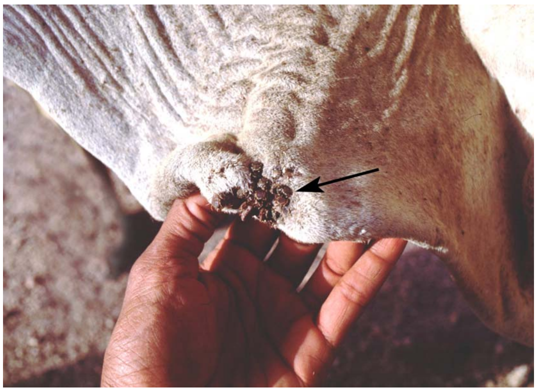
How to sample ticks.

Collection of ticks from hosts.

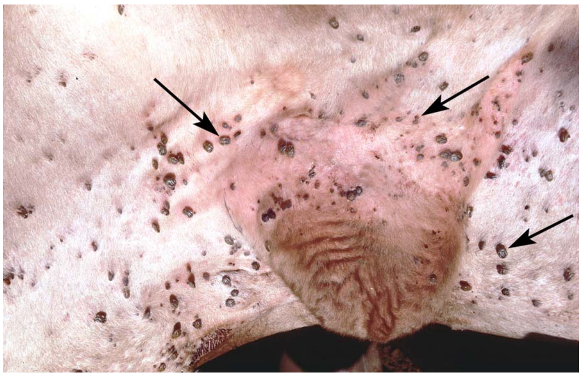
Tick specimens are usually collected from their hosts. It is often most efficient to examine selected areas of the host. This is very useful for ticks that are known to have sites where they prefer to feed (= predilection sites). For example on a herd of cattle *Rh. appendiculatus* adults will be mostly found on the cattle's ears, *Am. variegatum* will be on the dewlap, axillae, udder and groin, *Rh. decoloratus* (= *Rhipicephalus (Boophilus) decoloratus*) or *Rh. microplus* will be more generally on the shoulders, dewlap, and belly, *Hyalomma truncatum* and *Rhipicephalus evertsi* will be mostly around the anus. An effective way to detect adult ticks, specially when they are engorging, is to feel the hair coat of the host with the palm of your hand. Smaller domestic animals in a clinic can be examined in the same way. To find immature ticks or unfed adults the hair can be parted systematically using forceps as a comb.

To remove ticks it is necessary to use strong steel forceps. These should be of medium size with blunt ends and serrated inner surfaces. The forceps is used to grip the tick firmly over its scutum and mouthparts as closely to the host's skin as possible, then the tick is pulled strongly and directly out. For identification of *Rhipicephalus* species it is important to examine details of the mouthparts closely but they may be damaged during removal of the tick from the host. It is important to have males in addition to females for identification; they have more useful features. Take care to remove the males which often re-attach for mating pressed to the ventral side of engorging females, near their genital aperture.

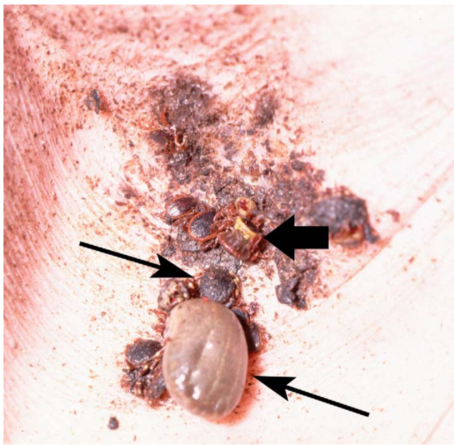
***Rhipicephalus appendiculatus* on ear.**



***Amblyomma variegatum* on dewlap.**



***Rhipicehalus decoloratus* on belly.**



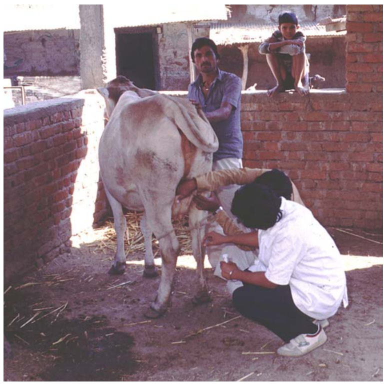
***Rhipicephalus evertsi* (thick arrow) and *Hyalomma truncatum* (thin arrows) near anus.**

If the ticks are required live they should be placed in strong tubes containing a piece of damp paper. During collection it is useful to seal the tube with a rubber membrane made from rubber gloves or similar material and held with a rubber band or tape. This should have a small slit cut in it through which the ticks are pushed. For transport to the laboratory use a separate ventilated plug. This can be made of cotton wool or a perforated screw cap. These tubes should be labelled then kept in a sealed plastic bag containing wet cotton wool or paper to maintain high humidity. The ticks should be kept cool over ice but take care not to freeze them fatally. To preserve the ticks at the collection site place them direct into 70% ethanol (8 parts of 90% ethanol plus 3 parts of water), or 5% formalin (5 parts of 40% formaldehyde solution plus 95 parts water). If the ticks are to be used for analysis of nucleic acids then the specification of the preservative should be checked with the needs of the tests to be used. If in doubt use only pure 100% ethanol.

Tick sampling tubes and forceps.

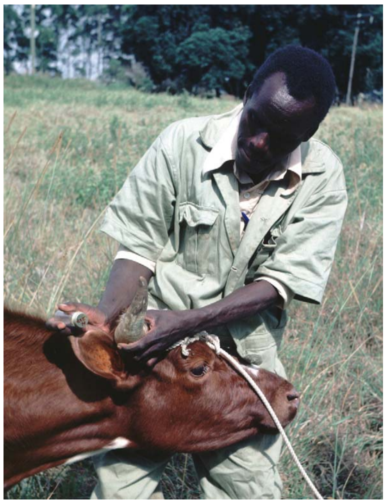
Ticks collected in the field should be placed in 25 to 30ml capacity glass tubes with thick walls and metal caps. These are usually known as Macartney or Universal tubes. Their thick glass walls make them more durable than plastic tubes. To label collection tubes in the field the best method is to use lead pencil writing on strong paper or card to make a small label. This is placed inside the tube with the ticks. Labels on the outside of the tubes should only be written on adhesive tape wrapped completely around the tube. Field collection data should include date, site, collector, host species and other information relevant to the study.

Calf cast to the ground for count of all ticks on half body.



Palpating with palm of hand for *Hyalomma* ticks on udder of dairy cow.

Squeeze crush for experimental study of effects of tick infestation.



Selective sampling of ears. An experimental calf used as a sentinel animal to assess rate at which ticks attach in the field.

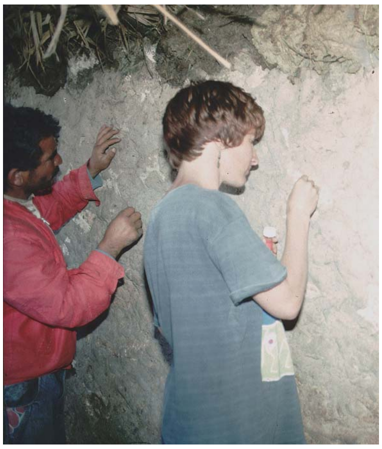
Collection of ticks from vegetation and other environments.

Some species of ticks can be collected whilst they are unfed and questing on vegetation. If they are sufficiently dense in numbers adult *Rh. appendiculatus* and other ticks can be picked from grass stems. More often it is efficient to use a trap which mimics a host. This consists of a cloth 1m square which is dragged slowly across the vegetation for 5m to 10m (for approximately 30 seconds of walking; or a longer distance depending on local knowledge). Larvae, nymphs and adults will grip onto the dragging cloth temporarily and can be collected with a forceps. A white cloth of cotton towelling is effective. It is fitted with a bar at the front and a cord for pulling it. This method works well for larvae and nymphs of questing species but is less efficient for adults and hunting species. A sweep net can be used to collect adults which quest on long vegetation; these are made of a very strong frame with a thick cloth bag. Traps using carbon dioxide as an attractant can be used to collect hunting ticks.

Cloth drag (bottom) and sweep net (top).
The cloth drag is 1 metre square.

Cloth dragging for *Ixodes ricinus* in woodland.

Endophilic and domestic ticks can be collected direct from the nests or shelters of their hosts using forceps to probe in cracks and under pieces of dry dung, spiders webs etc. This is very effective for moulting nymphs and adults of *Hyalomma* ticks in cattle housing. *Ornithodoros* ticks can be collected in the same way. These ticks are also auto-fluorescent in ultraviolet light. This makes them easy to see at night if illuminated with a portable ultra-violet lamp. In Africa most ticks are not a serious risk to humans but in some situations they may be a great risk, specially to people working closely with animals. When collecting in the field protect yourself by wearing long trousers over long boots and long sleeves with closures at the wrists.



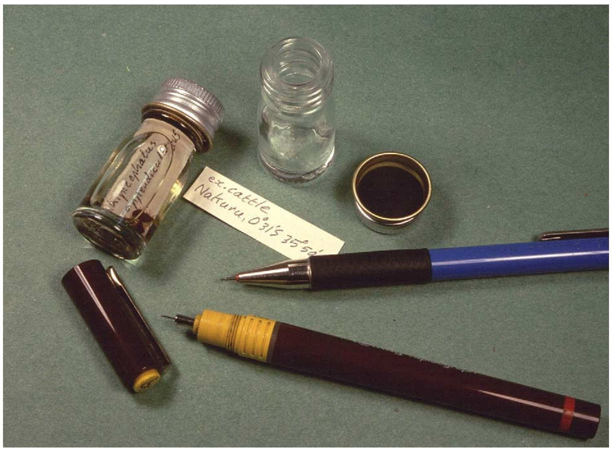
Collecting *Hyalomma detritum* from cracks in wall of housing for dairy cattle.

Collecting *Hyalomma anatolicum* from under dried dung at dairy cattle pen.

Preservation and labelling of ticks.

Collections of ticks are stored in liquid. This is usually 70% ethanol with glycerol (use 90% ethanol, to 80ml of this add 15ml of water and 5ml of glycerol). The glycerol protects the ticks from drying out when examined. The best tubes for storing ticks are those with thick glass walls and metal screw caps with a rubber washer, of approximately 5ml capacity and known as bijou tubes. Never use plastic containers for storing ticks in a collection because they slowly degrade then leak.

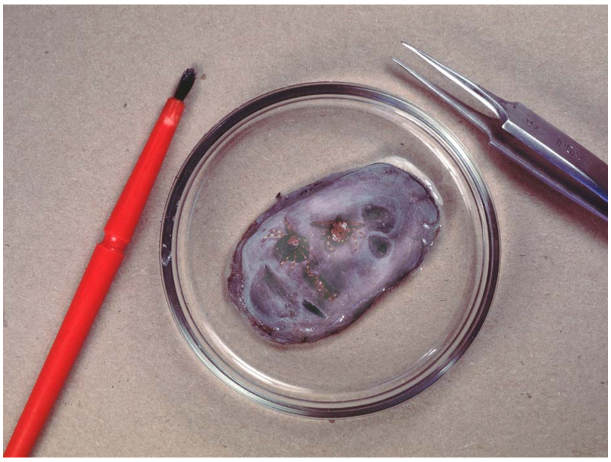
Labels for tick collections should be written on card using only India ink (= China ink) which is carbon based and will not dissolve. A fine draughtsman's pen is necessary for this. The label should include name of the species (if known), date, collector, species of host, site and country of collection. The site should be given as both a permanent place name and as latitude and longitude. The use of village names or similar changeable features makes difficulties for later workers. The universally accepted system is to use global coordinates of latitude and longitude, to at least the nearest minute. These are read from a map or atlas of the area, or from an instrument receiving data from satellites



Equipment for preserving ticks for identification.

Observing and recording ticks.

Ticks can be identified to genus using the naked eye or a simple hand lens of x10 magnification. To identify most species a dissecting microscope is essential. This is a low power stereoscopic microscope. It must have a range of magnification from x10 to x40, and preferably up to x60 or x80. Good lighting is essential; this requires a special lamp. The best type has a cold light source from a bulb of high intensity and is fitted with a flexible light guide.



Equipment for viewing ticks for identification.

For preliminary sorting keep the ticks in a dish under the preserving liquid. For some features such as leg colouration observe the ticks under liquid. For final identification examine ticks dry and cleaned of deposits of glycerol from the preservative. Use tissue paper to blot them dry. When dry the ticks often reveal dirt on their surface. Clean them using an ultrasonic cleaner whilst they are immersed in 5% sodium or potassium hydroxide solution in water. If a cleaner is not available then obtain a very fine artist's brush and cut the bristles down to a small stump. Immerse the tick in a solution of detergent and use this stump to clean the tick. If cement adheres to the mouthparts use a fine forceps to pull it off whilst gripping the tick with a medium forceps. It is most important to view the tick from different angles to observe features of superficial texture such as punctations and grooves. Use a piece of artist's modelling material such as "Plasticine" which can be fixed to the bottom of a small dish and moulded into a stand of various angles on which to view the tick. The strong lighting will dry out the tick and make it brittle. To avoid this replace it in the preservative regularly, or have the Plasticine stand surrounded with water and place a lid over the viewing dish when it is not in use.

Features confusing for identification.

The relative sizes of larvae, nymphs and adults when unfed and fed are shown in the photograph on page 6 of the life cycle of *Rhipicephalus appendiculatus*. It is most important to be familiar with these different sizes. Engorged ticks are difficult to examine but most of the features can be seen if the tick is positioned on a viewing stand. Cement or a spermatheca or a mating male may be found attached to feeding females and should be removed. An engorged *Amblyomma* nymph can be same size as an engorged boophilid female found on the same host but they can be identified to genus by comparing the mouthparts and coxa. Also nymphs have no genital aperture.

Objects confusing for identification.

Engorged nymph of *Amblyomma variegatum* (left) compared to engorged female of a boophilid tick, *Rhipicephalus microplus* (right).

How to identify ticks.

Identification keys.

The best known method for identification is the dichotomous key. This provides a series of choices between two or more features of ticks at each stage. If each choice is made correctly the key leads to a single species. This type of key remains the best method for identifying any species of tick from the wide variety that may be found on domestic and wild hosts in Africa. They can be provided in a computerised version.

There are also multiple entry keys that are designed for the advantages of computers. These use a database of all the available features of the ticks for identification. The user is prompted to answer a question and the answer leads to another question. This seems similar to a dichotomous key, however if the user cannot answer the question more questions will be provided from the database until it is possible to proceed.

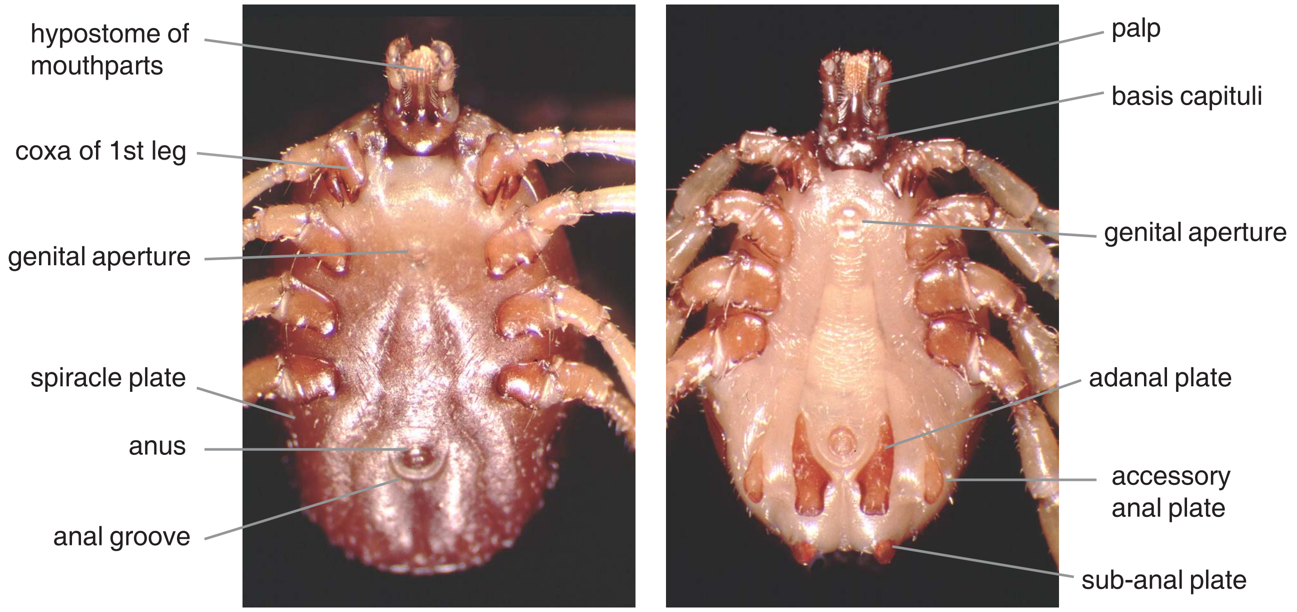
Pictorial guides can be made for ticks. These are similar to those for amateur use to identify birds or butterflies. These work best for a limited number of species, such as those which commonly feed on domestic animals. The same features used in dichotomous or multiple entry keys are presented as a list of those that can be seen from a particular specimen, together with detailed illustrations.

External structure.

The illustrations on page 16 show the main features of the external structure (= morphology) of ticks. Larvae have three pairs of legs, a scutum covering the anterior dorsal surface and no genital aperture. Nymphs have four pairs of legs, a scutum and no genital aperture. Females have four pairs of legs, a normal scutum and a large genital aperture. Males have four pairs of legs, a conscutum covering most of the dorsal surface and a genital aperture in the same position as the female. Larvae and nymphs can usually be placed in the correct genus by comparison with the mouthparts and coxae of adults. Identification of immature ticks to species is work for an expert but it is helpful for identification of immature ticks to species if they are closely associated with a dominant species of adult.

Coloured patterns occur on some ticks as a pigment (= enamel) in the outer body wall. It occurs on the scutum, conscutum or legs (see page 21). The presence of pigment is known as enamelling or ornamentation and such ticks may be called ornate. The colour is usually ivory white but in *Amblyomma* ticks it is often orange and green. However, this colour has limited use for identification of ticks. Even with the colourful *Amblyomma* ticks it is the pattern made by the light coloured enamel against the dark uncoloured body wall that is more important than the actual colour of the enamel.

External structure of *Hyalomma anatolicum*, dorsal view. Female at left, male at right.



External structure of *Hyalomma anatolicum*, ventral view. Female at left, male at right.

Diseases associated with ticks.

Direct parasitic damage.

When ticks feed a wound is created in the skin. This is usually a sterile abscess and will heal to form a small scar. The inflammatory and hypersensitive reactions at the feeding site are irritating and painful. When ticks such as *Hyalomma truncatum* attach between the claws of the feet of sheep they cause lameness. When *Amblyomma variegatum* attaches on the teats of cattle there is interference with suckling. Boophilid ticks in large numbers on the back and flanks of cattle make many small scars in the skin, so that when the skin is processed for leather, blemishes appear that reduce the value of the leather.

Ticks suck much blood from their hosts; when they are feeding in large numbers this causes anaemia and loss of nutrients. In addition the irritation of the ticks makes cattle anorexic; reducing food intake. All these factors reduce the gain in liveweight of cattle: for engorging *Rh. microplus* female (known as a *standard* tick) there is 0.6g loss of liveweight gain to the cattle and for *Rh. appendiculatus* the equivalent datum is 4.0g. Similarly the feeding of *Amblyomma* ticks on cattle leads to loss of milk production.

Damage in leather made from hide of cow that had boophilid infestation. The white areas that have not taken up the dye were feeding sites of the ticks.

***Amblyomma variegatum* adults on teats of cow.** This is a preferred feeding site of this species.

***Rhipicephiaus microplus* stages of engorgement.** On the left are unfed male (upper) and female (lower), in the centre are females at stage 1 then stage 2 of feeding, at the right are three *standard* females in stage 3 of feeding in the last 24 hours before detaching.

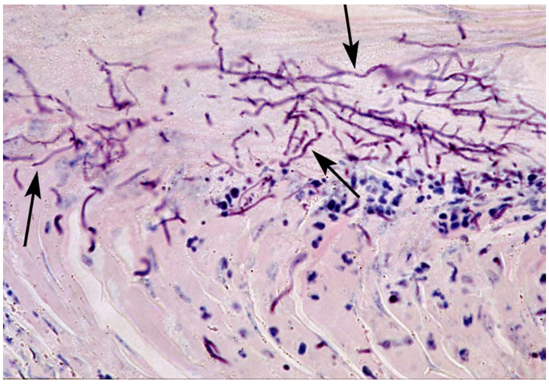
A *standard* female *Amblyomma variegatum*. This recently detached tick weighed 5 grammes and it may have consumed 50ml of blood to gain this weight.

Toxicosis and dermatophilosis.

Some ticks secrete toxins in their saliva. It is unclear why this happens but it causes several types of poisoning or toxicosis. Sweating sickness is a moist eczema caused by the feeding of *Hyalomma truncatum*. Females of *Rhipicephalus evertsi* and *Ixodes rubicundus* may cause paralysis to sheep, goats and cattle when they are engorging. The paralysis of sheep by *Ix. rubicundus* is known in South Africa as Karoo paralysis. *Ornithodoros savignyi* bites on camels and cattle are very painful and cause stress.

Ticks feeding in large numbers can cause a systemic suppression of their host's immunity and this may allow other diseases to become worse. Even small numbers of *Amblyomma variegatum* ticks feeding on cattle suppress immunity such that any infection with *Dermatophilus congolensis* bacteria in the skin is aggravated to cause very severe dermatophilosis. The *De. congolensis* is not a tick borne pathogen and the feeding sites of ticks do not encourage the mechanical entry of this pathogen into the host.

Sweating sickness in a calf. Caused by the feeding of adult *Hyalomma truncatum*.



Filamentous form of *Dermatophilus congolensis* in the epidermis of a cow. Giemsa's stain.

Dermatophilosis in a steer. Associated with an infestation of *Amblyomma variegatum* adults.

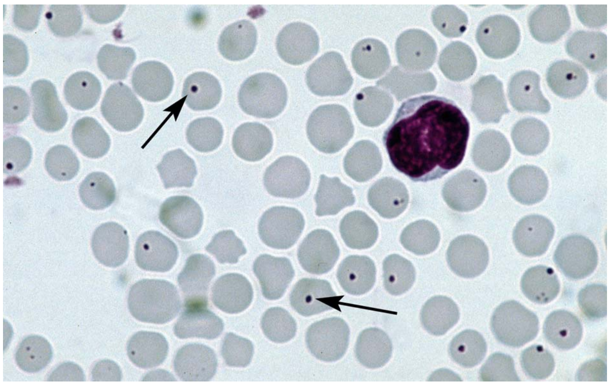
Common diseases caused by pathogens transmitted by ticks.

African swine fever. This is caused by a virus of the same name of the family Iridoviridae. In Africa it is transmitted to domestic pigs by *Or. porcinus domesticus* and *Or. p. porcinus*; these are in the *Ornithodoros moubata* complex of tick species. The virus causes haemorrhage, leukopenia and pyrexia.

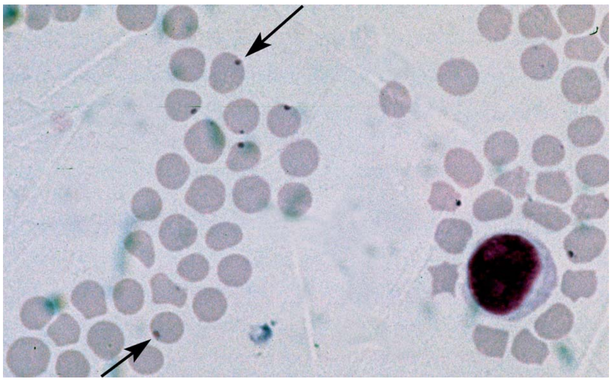
Anaplasmosis (= gallsickness). This is caused by a rickettsial bacterium, usually *Anaplasma centrale* or *An. marginale*. These infect red blood cells and a severe anaemia may be caused. Transmission is by ticks of many species particularly boophilids and involves development in the tick. *Anaplasma* can also be transmitted mechanically by biting flies and contaminated needles. The form usually seen in diagnosis.

An *Ornithodoros* adult tick. (This is *Or. savignyi* which is not a vector of African swine fever virus).

appear as small densely stained bodies in red blood cells, mostly at the centre in *An. centrale*, or at the margin in *An. marginale*.

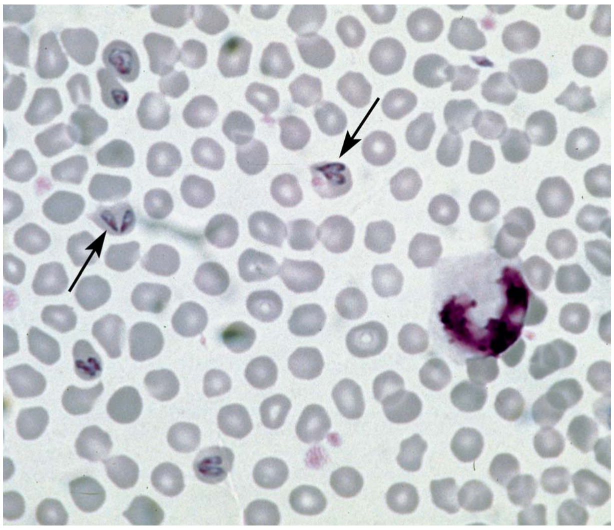


***Anaplasma centrale* in cattle blood.**
Giemsa's stain.

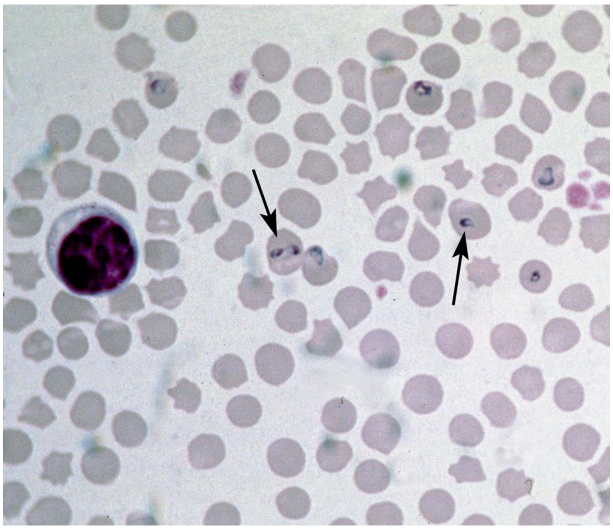


***Anaplasma marginale* in cattle blood.**
Giemsa's stain.

Babesiosis (= red water fever). This is caused by intracellular protozoans. The most important species in Africa are *Babesia bigemina* and *Ba. bovis* which parasitize cattle and *Ba. canis* which parasitizes dogs. These infect mainly red blood cells causing anaemia and systemic inflammation. *Babesia bigemina* is transmitted by the boophilid cattle ticks *Rh. annulatus*, *Rh. decoloratus* and *Rh. microplus*, whereas *Ba. bovis* is transmitted by *Rh. microplus* and *Rh. annulatus*. *Babesia canis* is transmitted by the dog tick *Rhipicephalus sanguineus*. In diagnostic blood films these pathogens are seen as the piroplasm stage within red blood cells. They are single or paired cells, with a small nucleus at one side.

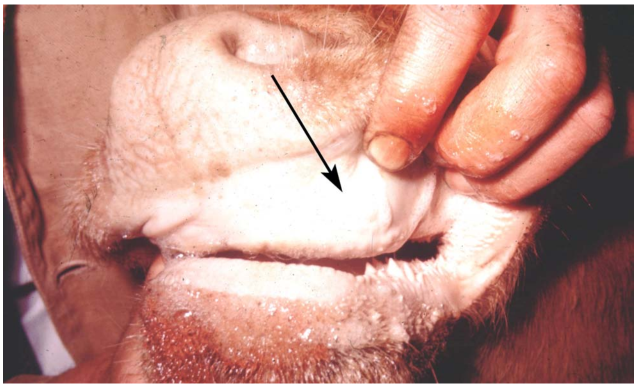


***Babesia bigemina* piroplasms in cattle blood.**



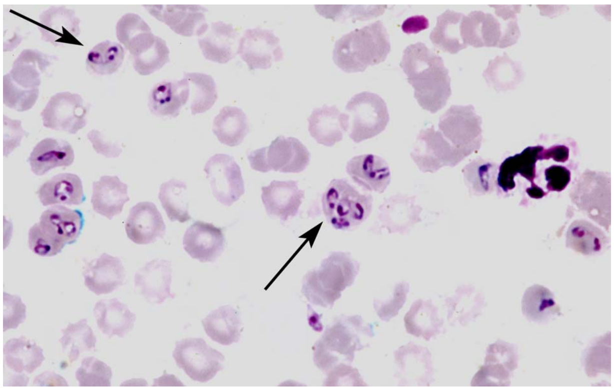
***Babesia bovis* piroplasms in cattle blood.**
This pair of blood films are stained with Giemsa's stain.

***Boophilus microplus* female (left) and male (right).**
This species transmits both *Ba. bigemina* and *Ba. bovis*.



Sign of anaemia in a cow with babesiosis. Pale gums.

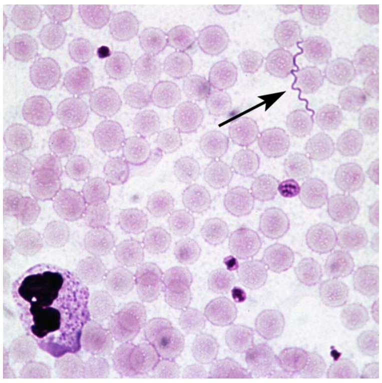
Sign of haemolytic anaemia in urine of cow with babesiosis. Haemoglobinurea, or redwater.



***Babesia canis* piroplasms in dog blood**. Giemsa's stain.

Rhipicephalus sanguineus. The tropical dog tick.

Borreliosis. This is caused by several types of spirochaete bacteria. Of most importance in Africa is *Borrelia duttoni* which causes relapsing fever in humans and is transmitted by *Or. porcinus domesticus*. The pathogens multiply within the blood plasma and cause repeated fevers, hypotension and weakness. *Borrelia theileri* commonly infects cattle blood and is transmitted by boophilid ticks, but usually little disease is caused.



***Borrelia theileri* in bovine blood.** Giemsa's stain.

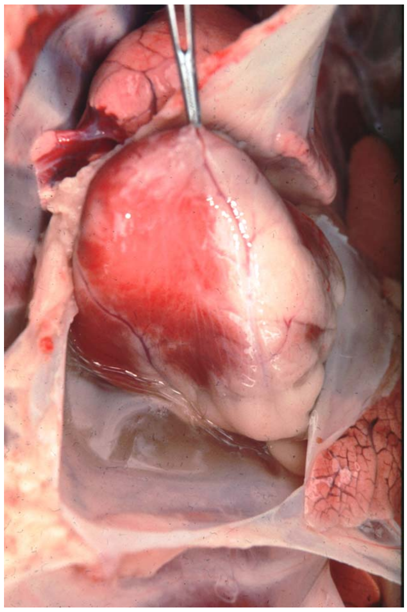
Crimean-Congo haemorrhagic fever. This is caused by a virus of the same name and of the family Bunyaviridae. The disease occurs in humans and is characterised by severe haemorrhage with kidney and liver failure. The virus is transmitted by several species of ticks, commonly *Hyalomma marginatum* and *Hy. rufipes*.

***Hyalomma rufipes*, female (left) and male (right).**

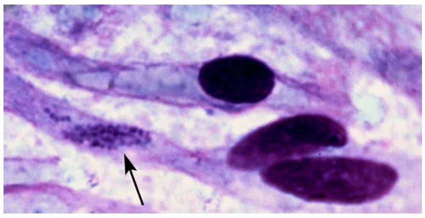
Cowdriosis (= heartwater). This is caused by a rickettsial bacterium, *Ehrlichia* (*Cowdria*) *ruminantium*. This is transmitted to sheep, goats and cattle by *Amblyomma* species, mainly *Am. variegatum* and *Am. hebraeum*. The bacteria multiply in the endothelial cells of blood vessels, specially in blood vessels of the brain. Acute infection causes severe oedema (specially into the pericardium and brain). Diagnostic smears of brain tissue show characteristic purple staining morulae of the bacteria in endothelial cells.

Sign of cowdriosis in a kid. Prostration with lateral recumbency.

***Amblyomma hebraeum*, female (left) and male (right).**



Sign of cowdriosis. Hydropericardium (thus the name heartwater).



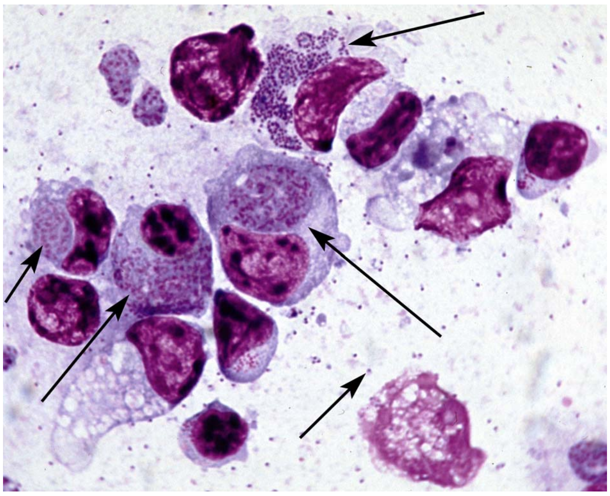
***Cowdria ruminatium* morula in brain endothelial cell.** Giemsa's stain.

Ehrlichiosis (canine form). This is caused by the rickettsial bacterium *Ehrlichia canis* and this pathogen is transmitted to dogs by the tropical dog tick *Rhipicephalus sanguineus*. The pathogen infects monocytes and lymphocytes. In severe cases a haemorrhagic and oedematous disease is caused known as tropical canine pancytopenia. *Ehrlichia bovis* and *Eh. ovis* infect cattle and sheep respectively but seldom cause disease. Note that some *Ehrlichia* species are now classified in the genus *Anaplasma*.

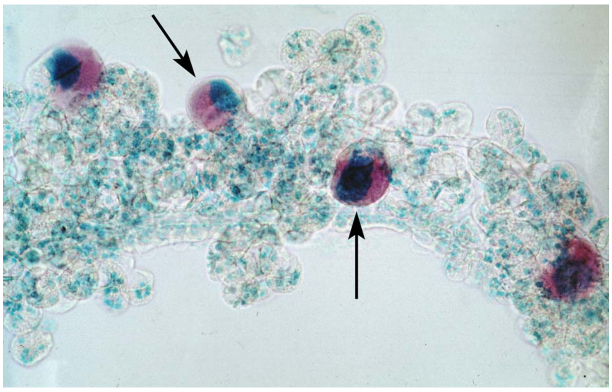
Rickettsiosis (human tick typhus or tick fever). This is caused by *Rickettsia conorii* bacteria transmitted to humans by immature stages of a variety of ticks including *Rhipicephalus sanguineus, Rh. appendiculatus* and *Amblyomma hebraeum*.

Theileriosis (= tropical theileriosis and East Coast fever). This is caused by protozoans that infect the lymphocytes, macrophages and red blood cells of cattle. Tropical theileriosis is caused by *Theileria annulata*. The pathogen is transmitted mainly by *Hyalomma detritum detritum* and *Hyalomma anatolicum anatolicum*. These ticks in Africa are confined to countries on the Mediterranean and in Sudan. The stages found in the tick are the gametes in the gut, the kinete which migrates from gut to salivary glands, and the sporoblast and sporozoites in the salivary gland. Field collected ticks can be dissected and their salivary glands removed and stained to show sporoblasts. This gives the data of infection prevalence and abundance, which are important for epidemiology.

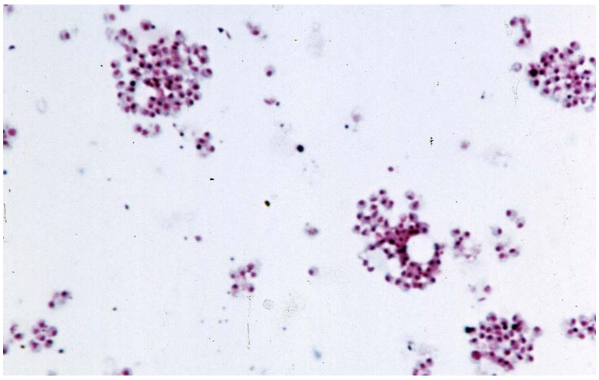
East Coast fever is caused by *Theileria parva*. This protozoan is transmitted by *Rh. appendiculatus* which occurs in eastern, central and southern Africa. Theileriosis is characterised by lymphoproliferation leading to severe oedema. Smears of enlarged lymph nodes reveal the schizont and merozoite stages within leucocytes and blood smears reveal the piroplasms as small nucleated cells within red blood cells.



***Theileria annulata* schizonts and merozoites in smear of lymph node.** There is one mass of merozoites at top, three schizonts centre and many free merozoites. Giemsa's stain.

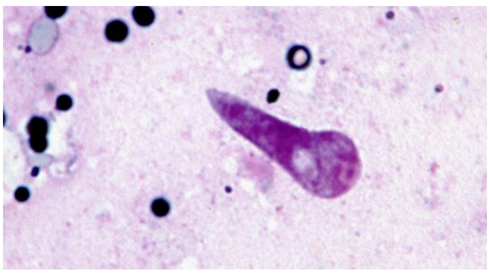


***Theileria annulata* sporoblasts in salivary gland of *Hy. anatolicum*.** The immature sporoblast stains red for RNA, the enlarged nucleus of the infected salivary gland cell stains green for DNA. Methyl green and pyronin stain.



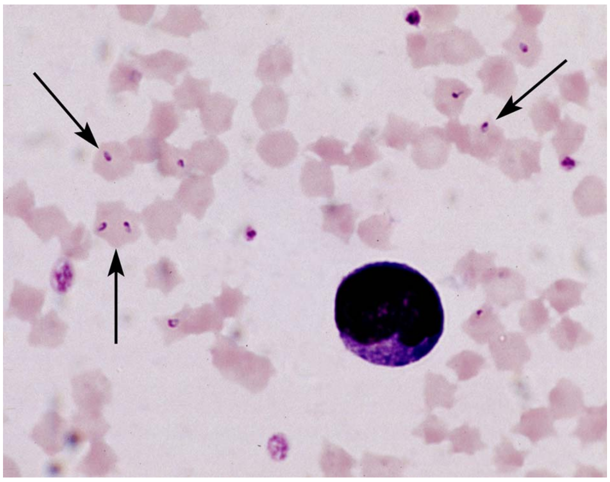
Sporozoites of *Theileria annulata*, purified from ground up ticks. Giemsa's stain.

***Hyalomma detritum*, female (left) male (right).**

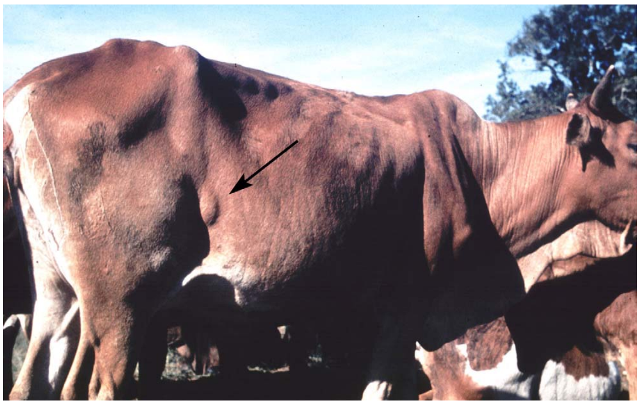


***Theileria* kinete.** From a smear of tick haemolymph. Giemsa's stain.

***Hyalomma anatolicum*, female (left), male (right).**



***Theileria parva* piroplasms in cattle blood.** Giemsa's stain.



Clinical sign of theileriosis - swollen lymph nodes. This cow had a carrier infection of *Th. parva*.

Tick control.

Introduction.

The commonest reason for controlling ticks on livestock is to prevent diseases caused by tick transmitted pathogens. The important diseases are anaplasmosis, babesiosis, cowdriosis and theileriosis. Some cattle herds may be subject to serious threat from two or more of these diseases and this has lead to substantial use of tick control systems, mostly relying on chemicals that kill ticks (= acaricides). This has contributed greatly to development of the livestock industy in Africa.

***Rhipicephalus appendiculatus*, female (left), male (right).**

However there are many problems associated with it and additional methods are needed. Conventional acaricide use can be difficult to make profitable; it often has a poor ratio of cost to benefit. If acaricides are used intensively livestock will not be exposed to disease pathogens and fail to acquire natural immunity. When this occurs the livestock have increased susceptibility to disease and a situation of endemic instability arises: disease outbreaks are likely if acaricide use is not maintained. It is often best to achieve a state of endemic stability where there is sufficient exposure to ticks and transmitted pathogens to give high levels of naturally acquired immunity in the population of livestock. Some animals will be lost to tick borne disease but the cost may be less than the cost of intensive treatment. It is also important to reduce contamination of the environment and livestock products with acaricides and to reduce the rate at which ticks become resistant to the acaricides.

Conventional use of acaricides.

Acaricides are usually applied to cattle in dipping tanks or baths. These contain about 15,000 litres of a water based dipping fluid containing the active acaricide. Cattle are forced to swim through the tank and become soaked in acaricide. The surplus dip wash then drains back to the tank. Soaking of the cattle is effective but it is difficult to keep the dipping fluid fresh. For some types of problem, such as *Hyalomma* ticks on feet of sheep, a foot dipping bath is used.

Spray races are often used because they have the advantage of using smaller amounts of spraying fluid and this is easier to keep fresh. The cattle run through a heavy and low pressure spray to become soaked, but areas like the ears and groin may not be treated fully.

Cattle dip tank. The entrance race, upper walls, rain roof and at far right the draining race are shown.

Sheep dip tank. A circular swim type, used mainly to control sheep scab mites but also for tick control.

Steer emerging from dipping fluid. It is completely soaked in acaricide wash; excess wash will drain back to tank from the draining race at the exit

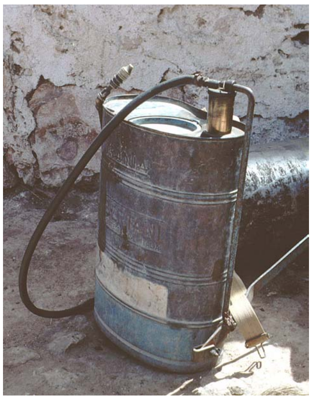
Internal construction of dip tank. Jump off point at far end, deep narrow tank, splash walls and exit steps at near end are shown.

Small numbers of livestock can be treated with hand held sprayers. The usual type is a pressurised container as a back-pack with a spray lance. These deliver a heavy wetting spray to soak the whole animal. They are cheap to buy, but wasteful of acaricide. Selective treatment of preferred attachment sites may be delivered with small domestic sprayers, however there is a danger of encouraging resistance to acaricides with partial treatments like this.

Pour-on formulations of acaricides consist of a high quality oil which spreads through the greasy hair coat of livestock. It contains typically 1% of the active ingredient of the acaricide. An adjusted amount of the pour-on is applied according to the weight of the animal. Pour-on formulations are expensive to buy but there is no wastage and they can be cheaper per animal in the long term. Oily formulations can be applied as selective spot-on treatments. Similarly, if an acaricide is formulated in a grease then ears and other sites can be treated. The pour-on formulations also can be used in applicators to treat wild antelope on game reserves. The animals are attracted to a feed bait and contact a porous surface soaked with the pour-on oil. An example is the Duncan Applicator.

A cow entering a spray race. The spray is at high volume and low pressure to soak the cattle.

Construction of a spray race. The two spray hoops and connecting pipes, and protective crush bars are shown. The pump and acaricide reservoir are in the section at the right.



Hand spraying. At the left is a spray lance supplied by a separate pump on the ground; the cow needs to be thoroughly wetted with low pressure spray. In the centre is a back-pack sprayer which is pressurized with a pump handle. At the right is a small sprayer for selective application to preferred feeding sites of ticks.

Types of acaricides.

These are classified in chemical groups. The active ingredient of materials for sale have a standardized common chemical name, but there may be many different trade names for the formulations of one active ingredient. Only the common chemical names are listed here.

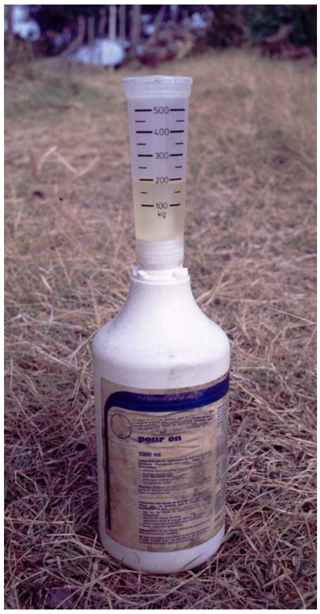
• The organophosphate group includes coumaphos and chlorfenvinphos; these acaricides have been in use for many years and tend to have problems of toxicity and acaricide resistance. They are soluble in oils and need to be diluted for use as an emulsion in water.

• The carbamate group includes propoxur which has sometimes been used as an acaricide.

• The formamidine group is represented by amitraz; this is an unusual acaricide because it is soluble in water and degrades rapidly, so it is made up fresh for each use. It is convenient for application in small hand sprayers.

• The synthetic pyrethroid group includes deltamethrin, fenvalerate and flumethrin. These are useful when older types of acaricide have resistance developed against them. However, there may be restrictions on their sale in some countries in order to reduce the rate at which new acaricides become poorly effective due to resistance. These synthetic pyrethroids can be formulated dilution in water or in oils as pour-ons.

• The phenylpyrazole group includes fipronil which is formulated for control of ticks on dogs.
• Botanical materials include extract of neem tree, azadiractin.



Pour-on acaricide use. Above, a cow is treated to control *Am. variegatum* in association with the dermatophilosis from which the animal suffers. At the right is a typical applicator, with the measuring pourer at the top of the main container.

Acaricidal treatment schedules.
These can be categorised as follows.

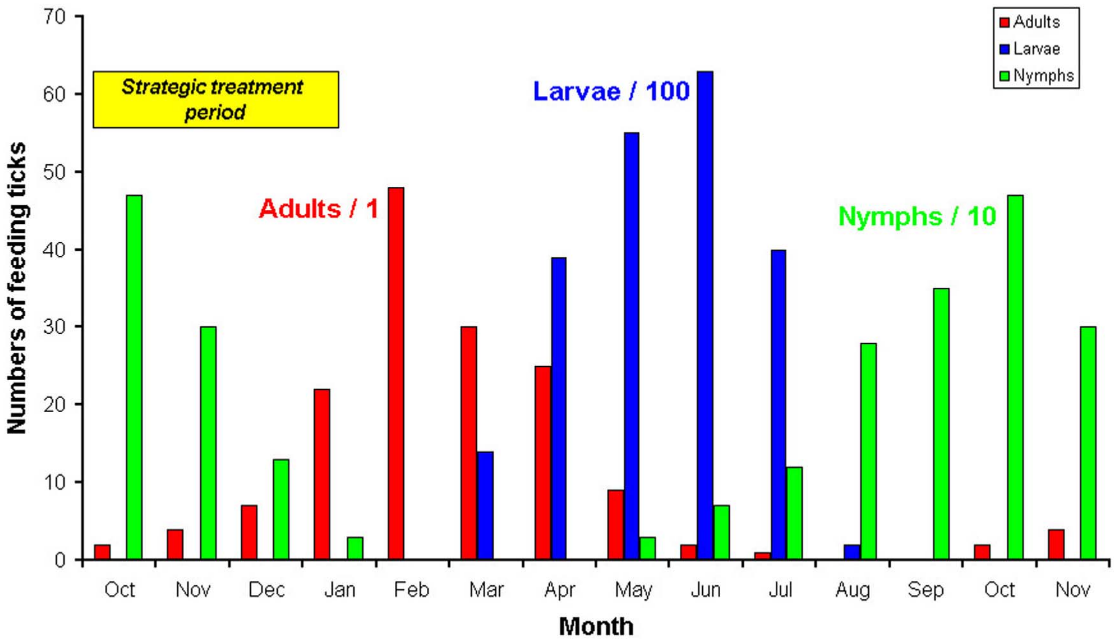
• Intensive treatment to achieve very high levels of control of three-host ticks aims to have constant availability of residual acaricide on the livestock sufficient to kill all ticks present or attempting to attach. Acaricide may be applied once per week or longer, depending on the residual effect of the acaricide used. This treatment is likely to reduce tick infestation so low that immunity to tick borne diseases is lost in the livestock, resulting in endemic instability.

Acaricidal grease. In use for selective control of *Rh. appendiculatus* on ears.

• Tactical treatment is when there is no intensive treatment but instead, when a heavy infestation of ticks is seen on livestock, they are treated and treatment may be at frequent intervals until the problem is seen to diminish. This is inefficient for protecting livestock against tick borne pathogens because by the time a heavy infestation is noticed on livestock there will be numerous infected ticks active on the pasture to re-infest the livestock.

• Threshold treatment is done according to a calculation of the cost of direct parasitic damage that an infestation of ticks may cause. This requires knowledge of the damage coefficient of the ticks, for example 4.0g loss of gain in liveweight caused by each standard *Rh. appendiculatus*, and the cost of dipping. It is only appropriate to use this when diseases cause by tick transmitted pathogens are under good control by other means.

• Strategic treatment is a system that uses ecological knowledge of the seasonal cycle of ticks. It works best in countries where there is a distinct season of feeding activity of adult ticks. Treatment of cattle is started when adults are becoming active but before their numbers become obvious. Treatment continues at sufficient frequency to maintain constant tick control during most of the season of adult feeding. This reduces greatly the number of eggs to continue the tick population and reduces acaricide use and other



Seasonal feeding activity of *Rh. appendiculatus* in southern Africa with a typical period of strategic treatment shown. The treatment period is timed at the beginning of the activity of adults. The height of the bars for larvae are reduced by 100 and for the nymphs by 10.

treatment expenses. Strategic treatment systems have been tested for *Rh. microplus* and *Rh. appendiculatus*. However, local knowledge of the seasonal activity of the ticks is needed. The adults are easiest to estimate and are probably the best stage for strategic control because of the impact on reproduction. The bar chart is based on data from several studies in southern Africa on the seasonal feeding activity of *Rh. appendiculatus*, **without** any control. Note that there are x100 more larvae and x10 more nymphs than appears. A possible timing for strategic treatment of 3 to 4 months is indicated. This treatment will suppress the natural peak of adults and result in many fewer larvae and nymphs than are shown, for the rest of the year. The remaining ticks are likely to continue transmitting tick borne pathogens at a low level. Endemic stability is likely to develop and the losses due to remaining tick borne disease are likely to be offset by reduction in cost of tick control.

Acaricide resistance.

When ticks are exposed to acaricides for a long time it is likely that some mutant strains of ticks will arise, by natural selection, that are able to survive the normal dose of acaricide. These are acaricide resistant strains and they may come to be the predominant type of tick in an area. This reduces greatly the effectiveness of the acaricide. This can be overcome by using a different type of acaracide but with the risk of producing strains of ticks resistant to many of the available acaricides. To slow down the rate at which this problem occurs there are several rules to follow. When acaricides are used they should be fresh and full strength as specified by the manufacturer. All the ticks on livestock being treated should be killed. The older types of acaricide should continue to be used until official veterinary advice is to change to another type. Newer types of acaricide should be kept in reserve for when all the older types become ineffective.

Stock breeding and pasture management.

Cattle breeds indigenous to Africa, typically *Bos indicus* or zebu, have a good, heritable, ability to acquire natural resistance to the feeding of ticks. This characteristic can be used in breeding programmes to produce crosses with more productive exotic cattle of the *Bos taurus* type which will give good resistance to ticks and good production. An example is the Bonsmara breed produced in South Africa. Herds of cattle usually have a small proportion of individuals infested with large numbers of ticks whilst most individuals are infested with small numbers. This is a typical distribution of parasites, called overdispersed or clumped. Persistently ticky cattle can be selectively culled to improve the tick resistance of the herd.

Effect of cattle resistance against *Rhipicephalus appendiculatus* nymphs. Top: nymphs fed on non-resistant calf. Bottom: nymphs fed on resistant calf; these are only half normal weight and will moult into small adults with reduced survival and reproductive potential, thus reducing the numbers of the tick population. Also see photographs on page 8.

Bull calves bred for good ability to acquire resistance to boophilid ticks in Australia. Cross of 50% Brahman (*Bos indicus*) with Shorthorn and Ayshire *Bos taurus*).

Ticks do not survive for long on pasture that is either heavily grazed and thus short and dry, or in areas where pasture land is rotated with crops. When intensively farmed land is fenced it is posible for cattle pastures to be cleared of ticks, by a combination of management and acaricide use, and then maintained tick free. This may be appropriate for control of boophilid species and *Rh. appendiculatus*. Burning of pasture grasses kills many ticks but should only be used when the main reason is to improve grazing availability. An extreme case of pasture management is zero-grazing of dairy cattle, but there is a risk of unexpected re-introduction of ticks on cut fodder or newly introduced animals. However, in the case of *Hyalomma* infestations of dairy cattle, the ticks are adapted to living within the cattle housing, so these methods do not apply. There is some use of spray treat ments of the walls of dairy houses to control *Hyalomma* ticks, but it is more effective in the long term to render the walls smooth with mortar.

Domestic fowl can be encouraged to eat ticks on cattle at kraals.

Additional methods.

There are vaccines commercially available in Australia and South America to control boophilid ticks. However, they are not sold in Africa and have insufficient effect on other species of ticks to be as widely effective as chemical acaricides. There have been many studies on the potential for biological control using parasites or predators of ticks but they have proved difficult to use in practice. Chickens will feed on engorging ticks on cattle and around livestock kraals and can be encouraged to contribute to tick control.

Integrated control.

This means the use of more than one method of control for greater efficiency and reliability. An example could be in the management of a herd of cattle that are threatened by East Coast fever and babesiosis. Firstly any vaccines against the transmitted pathogens should be used. In some countries there is an infection and treatment vaccine to control East Coast fever, in other countries there are blood vaccines to control babesiosis. Acute cases of disease may respond to anti-theilerial drugs such as parvaquone, and anti-babesial drugs such as imidocarb. If the *Rh. appendiculatus* ticks have a strong seasonal cycle of feeding activity then strategic treatment with acaricide could be more efficient than intensive treatment. If the cattle at risk are a susceptible exotic breed then cross bred cattle could be used instead. These could be equally productive in the long term because of their greater disease resistance. If dairy cattle are involved then pasture management towards intensive rearing systems could contribute to tick control.

Further reading.

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Wikipedia; WikiCommons and WikiBooks (www.wikipedia.com) provide free articles, photographs, diagrams, monographs and other information on ticks and tick-associated diseases.