

# Biological Sciences **review**

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## Get a grip

The secret life of ticks

**Plus**

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membranes work

Building a sustainable  
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# The secret life of ticks

Ticks have been known to us since the dawn of history. Aristotle (385–322 BC) believed that ticks were spontaneously generated from grass. Pliny the Elder (AD 23–79) thought that ticks must die after gorging on their victim's blood, because he was labouring under the misapprehension that they had no anus. However, it was not until the late nineteenth century that ticks were suspected of transmitting certain diseases.



Figure 1 A questing female of the sheep tick, *Ixodes ricinus*.  $\times 20$

Ticks are external parasites of vertebrates. They can survive only by sucking the blood of their host. They may use humans as one of their hosts. More than 50 species of ticks are known to feed on humans. Ticks are closely related to mites and more distantly to spiders and harvestmen. There are some 870 species of ticks recognised worldwide, of which 22 have been recorded in the UK. The most common tick in Britain is the sheep or wood tick (*Ixodes ricinus*) (see Figure 1).

Most ticks fall into one of two families: soft and hard ticks. Both groups differ considerably in life history and habits as well as in appearance. The hard ticks can be distinguished by the possession of a hard plate, or scutum, covering the dorsal body surface (see Figure 2). This article describes the main biological features of these hard ticks, and outlines some risks to human health associated with their bites.

## Life cycle

Ticks are most active in the UK from April to August. The life cycle of a tick takes from 1 to 6 years (typically 2 or 3) to complete. The precise length of time depends on the climate — mainly the temperature. Eggs are laid and then there are three active stages: larva, nymph and adult (see Figure 3 on p. 22).

The bodies of ticks are not segmented. The only discrete structure is the 'false head', or capitulum, which carries the mouthparts (see Figure 2). A blood meal is

required to develop from one stage to the next, and for the female to lay eggs. Each of the three stages seeks a host, attaches, feeds and then drops off. Most hard ticks (>90%) need three different host species,

## Key words

Parasites  
Disease vectors  
Disease reservoir

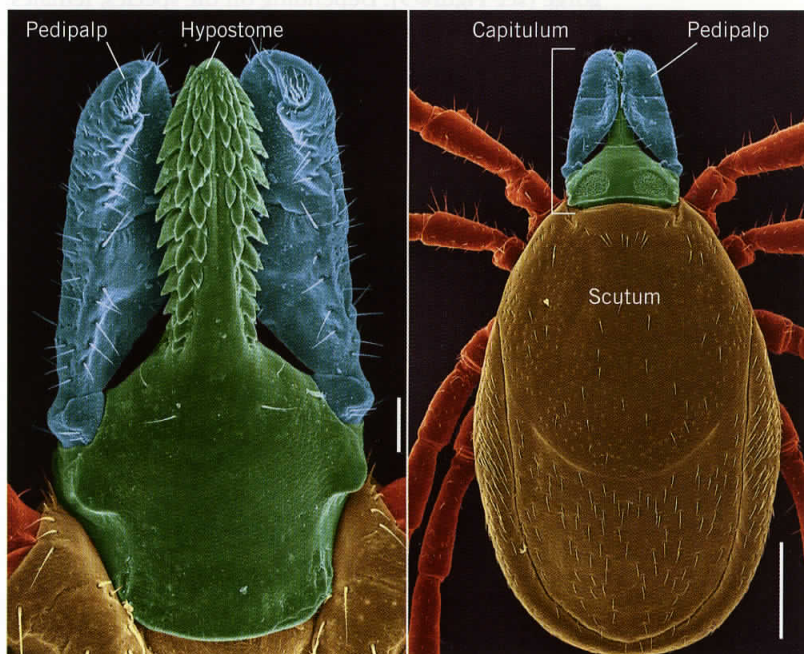
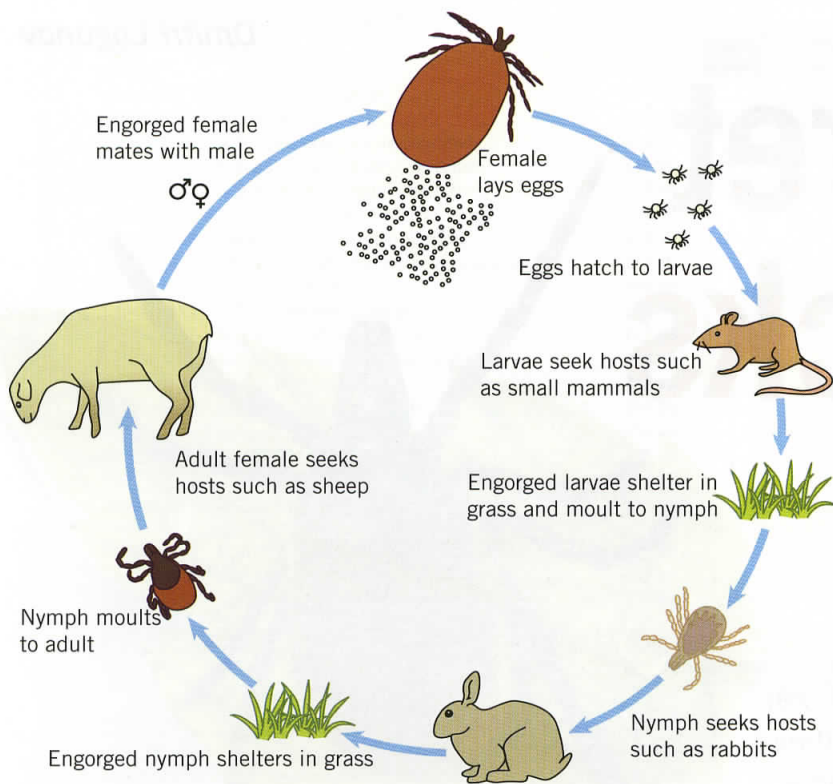


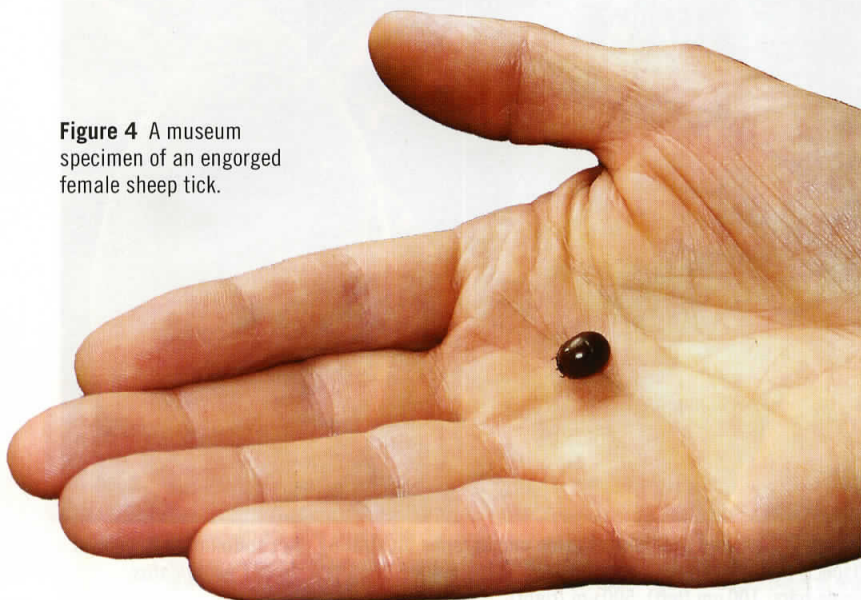
Figure 2 Coloured scanning electron micrographs illustrating the capitulum (left, ventral aspect) and body (right, dorsal aspect) of the female taiga tick, *Ixodes persulcatus*. Scale bars: 100  $\mu\text{m}$  (left), 500  $\mu\text{m}$  (right).



**Figure 3** Life cycle of the sheep tick.

one for each stage. Ticks feed slowly and only once at each developmental stage. Feeding lasts for several days: larva 2–6 days, nymph 3–8, and adult female 6–12. Many ticks are resistant to starvation and can survive for more than a year while waiting for a host (i.e. for their next meal). Females are capable of enormous swelling during feeding and can multiply their unfed weight by as much as 100–120 times (see Figure 4). But females do not fully engorge unless they have mated. Adult males feed briefly, or in some species not at all, and never gorge (see Figure 5). Depending on the species, females deposit between 1000 and 20 000 eggs, and then die. Eggs are typically laid in a single mass in leaf matter.

**Figure 4** A museum specimen of an engorged female sheep tick.



**Figure 5** An adult male of the sheep tick, *Ixodes ricinus*. ×18

### Host-finding and attachment

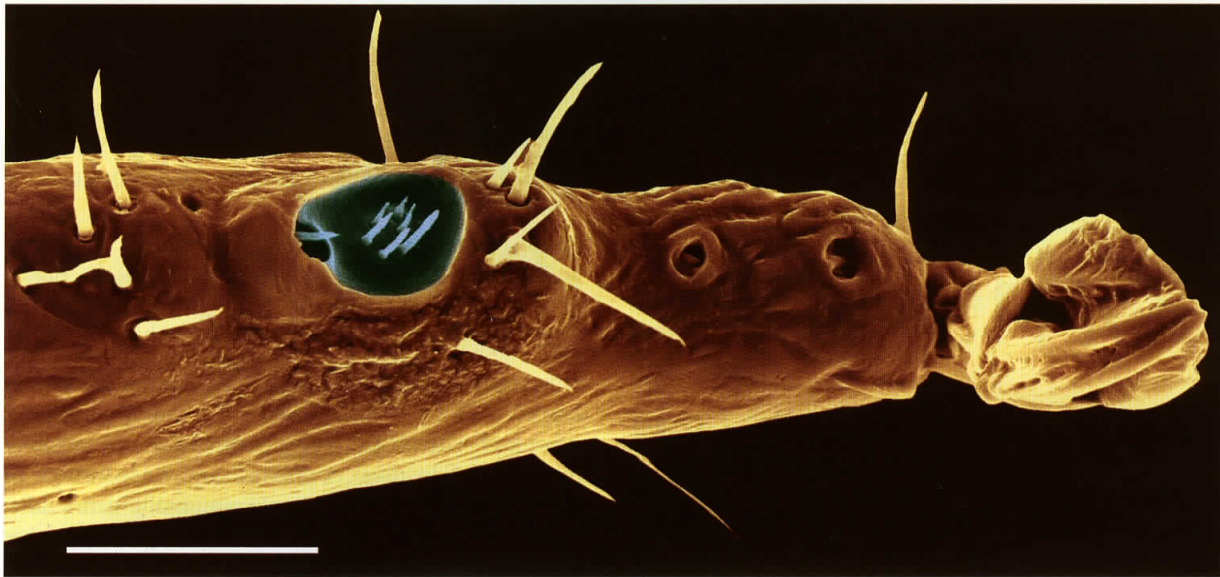
Ticks have limited mobility — most of them can only crawl slowly. Thus they must rely on passing animals for both food and transport. There are two main ecological groups of ticks: endophilic ticks (nest or burrow dwellers) and exophilic ticks (active host-seekers, living outside shelters).

The majority of hard ticks are nest dwellers. Typically, they remain hidden in animal nests and burrows during the whole life cycle. Since they do not actively seek out hosts they have to make do with whatever comes into the burrow or nest. Unsurprisingly, their host range is relatively narrow, sometimes being limited to just a single host. For instance, 99% of the tick *Ixodes lividus* are found on sand martins — birds that nest in burrows.

The host-seeking ticks constitute the remaining 10% of hard ticks and have at least two host-seeking strategies. They can actively ‘hunt’ hosts by attacking the host on the soil surface, or they can seek out hosts by climbing to the top of tall plants and simply waiting until a suitable host passes by. Ticks of this ecological group are usually able to feed on many different vertebrates. For instance, the hosts of the taiga tick (*Ixodes persulcatus*), which is widespread throughout the temperate zone of Eurasia, is known to include 200 species of mammals, 120 species of birds, and several species of reptiles. Such lack of host specificity demonstrates the ability and readiness of exophilic ticks to feed on any available host, including humans.

Most ticks have poor vision and are capable only of distinguishing between light and darkness. But all ticks have a unique and complex sensory organ, the Haller’s organ, located on the dorsal surface of the front pair of legs (see Figure 6). This vital organ detects and recognises various signals that are given off by potential hosts — changes in temperature, humidity, carbon dioxide concentration, and even airborne vibrations. It is thought that smell is the most important factor enabling a tick to locate a host.

Once it has found a suitable host, a tick attaches itself by means of sharp skin cutters and a barbed headpiece called a hypostome (see Figure 2). The hypostome also



**Figure 6** Coloured scanning electron micrograph illustrating the Haller's organ (blue) on the tick's first leg. Scale bar: 50 µm.

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serves as the food channel that directs blood into the tick's mouth. Once the mouthparts are buried into the skin of the host, the tick releases a cement into the wound site. The cement is secreted by salivary glands and serves as an adhesive for sealing up the gap between the mouthparts and the adjacent host tissue, ensuring that the parasite is not easily dislodged.

In order to feed successfully a tick has not only to attach itself tightly but also to stay undetected by the host. Tick saliva plays a crucial role. By secreting saliva, ticks can impair local itching and pain responses, prevent blood clotting, and suppress the local immune and inflammatory responses. This unique ability allows the tick to continue feeding unnoticed for as long as necessary.

### Tick-borne diseases

Tick bites are not inherently dangerous. They usually produce a mild allergic response with itching and localised swelling. However, as with many blood-sucking parasites, ticks are important vectors of an astonishing range of protozoan, viral, bacterial and rickettsial **pathogens** (see Table 1). Globally, tick-borne pathogens are likely to account for over 100 000 cases of illness each year.

**Table 1** Selected tick-borne diseases of humans (simplified from Dennis and Piesman, 2005)

Disease	Causative agent(s)	Primary tick vector(s)	Reservoir host(s)
Tick-borne encephalitis	Flaviviruses (family Flaviviridae)	<i>Ixodes ricinus</i> and <i>Ixodes persulcatus</i>	Rodents, insectivores
Lyme disease	Spirochetal bacteria <i>Borrelia</i> spp.	Several <i>Ixodes</i> species	Rodents, birds
Q fever	Bacterium <i>Coxiella burnetii</i>	Many tick species	Domestic livestock
Tularemia	Bacterium <i>Francisella tularensis</i>	<i>Ixodes</i> and <i>Dermacentor</i> ticks	Rodents, lagomorphs, others

However, none of the ticks are parasitic solely on humans. Thus the diseases they transmit cannot be easily eliminated because their other animal hosts act as natural reservoirs of infection. In the wild, ticks, their host(s) and the pathogenic microorganisms they transmit exist in naturally balanced systems, known as enzootic cycles. This is an established natural focus where the disease agent is quietly cycling between vertebrate reservoir hosts and their tick vectors. Only stressed individuals or those with lowered immunity show clinical disease symptoms of the pathogens carried by ticks. A stable cycle of the circulation of pathogen may become an unstable epizootic cycle when domestic animals are introduced or when tick-infested rural areas become urbanised. Domestic animals and humans have low or no natural resistance to the existing infection(s). When they come into contact with ticks and the disease agents they carry, tick-borne infections may be acquired with serious effects. Tick bites are the principal means by which most of these diseases are acquired by humans. Humans are always incidental, dead-end hosts, as they play little or no significant role in the enzootic cycles of tick-borne diseases. It must be remembered that most of the pathogens responsible for serious disease in humans are apparently harmless to their tick vectors.

Of the tick-borne diseases known to affect humans in the UK, Lyme disease is the most common (see Box 1 on p. 24). According to statistics from the Communicable Disease Surveillance Centre (UK), the incidence of Lyme disease is estimated at more than 250 cases per year. It is, however, the most frequently reported tick-borne disease across the world, with tens of thousands of cases every year.

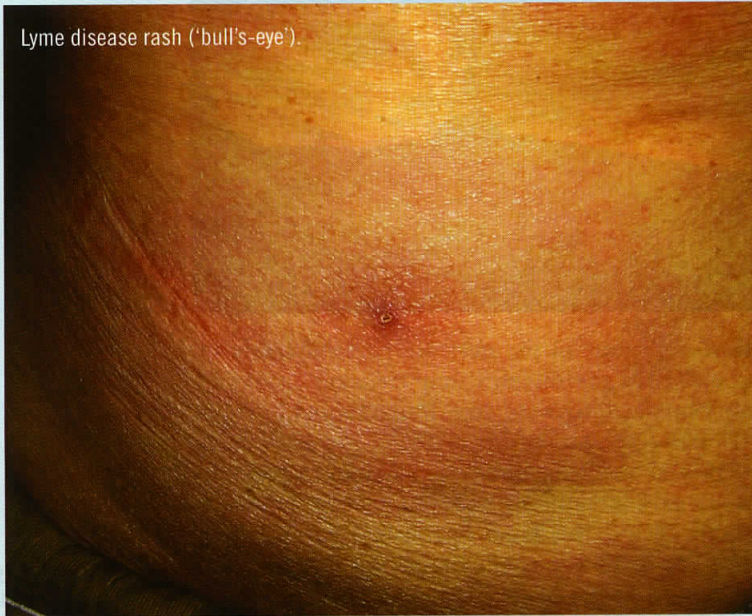
## TERMS explained

**Encephalitis** A brain inflammation of viral or other microbial origin.

**Pathogen** An organism (usually a microorganism) capable of causing disease.

## BOX 1 Symptoms of Lyme disease

Lyme disease causes a range of non-specific symptoms including fever, fatigue, flu-like symptoms, headaches, myalgia, muscle and joint pain. The specific symptom of Lyme disease, usually seen 7–10 days after a tick bite, is a characteristic skin lesion, known as ‘bull’s-eye’ rash (a reddish ring around the bite point). The rash is painless and not itchy. Lyme disease can be treated with antibiotics.



Lyme disease rash ('bull's-eye').

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## BOX 2 How to remove the attached tick

Never attempt to burn a tick off with a match head, or suffocate it with petroleum jelly etc. These folklore remedies do not help to detach the tick from the skin, but rather irritate and stimulate it to release additional saliva or regurgitate its gut contents, increasing the chances of transmitting pathogens. Simply use tweezers to grasp the tick close to the skin and to gently pull it straight up, without twisting. Disinfect the area with antibiotic cream.



The tick (*Rhipicephalus sanguineus*) attached to the skin.

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### Further reading

- Hendry, G. and Ho-Yen, D. O. (1998) *Ticks: a Lay Guide to a Human Hazard*, Mercat Press.
- Hillyard, P. D. (1996) *Ticks of North-west Europe*. Synopses of the British Fauna (New Series), No. 52, Natural History Museum.
- Mawby, T. (1998) 'Sheep ticks and human disease', *BIOLOGICAL SCIENCES REVIEW*, Vol. 11, No. 1, pp. 6–8.

### Control

Long-term attempts have been made to eradicate ticks responsible for human disease by the widespread applications of chemicals. These have been remarkably unsuccessful in most countries, and the strategy of killing ticks in this way is environmentally unfriendly. Biological control with pathogenic fungi or parasitic nematodes has potential but a commercial biological control agent has not yet been developed. The only vaccines for the prevention of tick-borne diseases currently in use are those against tick-borne **encephalitis** in Europe and Russia. In order to control tick-borne diseases, novel solutions for breaking links in the chains of transmission remain to be developed and applied. This task requires multidisciplinary teams of researchers and a broad geographic coverage.

The best way to prevent tick-transmitted infections is carried out by the individual. It involves minimising exposure in areas known to have disease-carrying ticks by avoiding walking in long grass without suitable clothing. Individuals need to take personal precautions, such as wearing long trousers, tucked into socks or boots if possible, wearing long-sleeved shirts, and using repellents on both skin and clothes. Inspect for ticks every few hours, since early detection and effective removal of an attached tick will minimise or prevent the risk of infection (see Box 2).

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### KEY points

- Ticks are external parasites that suck the blood of their vertebrate hosts.
- There are two main types of ticks — hard and soft. This article looks at hard ticks.
- Ticks must attach to their hosts, puncture the skin and remain unnoticed by their hosts while feeding — which can be for several days.
- Their saliva plays a crucial role in preventing their detection by the host — it minimises any inflammatory response and prevents the blood from clotting.
- Some ticks are limited to one host species while others can feed off a range of different hosts.
- Ticks can transmit a wide range of pathogens — the most common in the UK cause Lyme disease.