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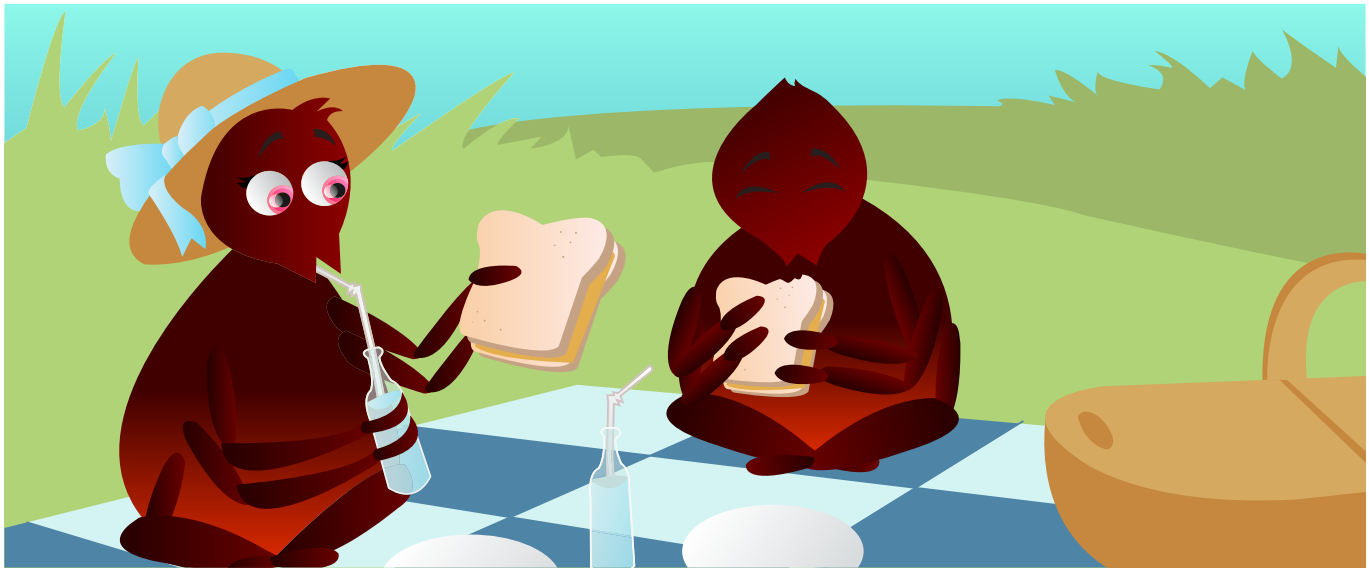

BE AWARE OF TICKS WHEN STROLLING THROUGH THE PARK

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Ticks are a type of organism found all over the world that feeds on blood. Ticks feed on many different animal hosts, including humans. Tick bites are usually not noticed by the host because tick saliva contains molecules that prevent inflammation (swelling) and pain. By remaining unnoticed by the host, ticks can often feed for several days without interruption. This causes a major problem since ticks can transmit disease-causing organisms while blood-feeding. This article provides information on how ticks evolved, their anatomy, life cycle, the diseases they transmit, and lastly, how to prevent tick bites.

TYPES OF TICKS

There are about 800 different kinds (species) of ticks, and they can be divided into three main families, called Ixodidae, Argasidae, and Nuttalliellidae. Ixodidae are also called hard ticks, and the structure they use for blood feeding (the **capitulum**) is visible. Argasidae are called soft ticks, and the capitulum

CAPITULUM

Mouthpart of ticks that includes the hypostome, two chelicera, and two palps.

is not visible. The major difference between soft and hard ticks is shown in Figure 1. Nuttalliellidae is considered as the evolutionary link between soft and hard ticks. This article focuses on hard ticks because they are the ticks that spread the most diseases to humans worldwide. We made up a name for all 650 species of hard ticks: *Ixodes solitarius*. We will use this name throughout the paper to make it easy to refer to all hard ticks but remember that there are no actual tick species with this name.

TICKS ARE COUSINS OF MOSQUITOES AND SISTERS OF SPIDERS AND SCORPIONS

Ixodes solitarius appeared on earth about 250 million years ago (MYA) [1]. It is very difficult to imagine how the ancestors of *I. solitarius* were. Since we cannot travel in time, scientists use a type of computer-based analysis known as **phylogeny**. Phylogeny is a method that shows how species that are alive now are related to species that existed in the past by analyzing the similarities and differences in their genes (DNA) or body characteristics. The **cladogram** in Figure 2 shows that mosquitoes, ticks, spiders, and scorpions had a single common ancestor around 700 MYA [2]. The body structure of ticks indicates that they are more closely related to spiders and scorpions than to mosquitoes. An easy way to remember this relationship is that adult ticks, spiders, and scorpions have eight legs, while mosquitoes only have six. However, it is important to note that *I. solitarius* have eight legs only when they are young or as adults, but when they first hatch from the egg, they only have six legs, like mosquitoes.

PHYLOGENY

A diagram showing the history of the development of something. In biology, phylogeny often refers to a diagram describing the evolutionary history of proteins or organisms.

CLADOGRAM

Graphic representation of a phylogeny.

TICKS AND THEIR ENVIRONMENT

The way ticks develop and interact with their environment is complicated, but it is important to understand how ticks develop and search for hosts. Any information about how ticks live is the basis for understanding the **epidemiology** of tick-borne diseases, meaning how these diseases spread and how we can control them. Since ticks are blood feeders, they must ingest large amounts of blood to completely develop. An adult female *I. solitarius*

EPIDEMIOLOGY

The study of how disease spreads and how it can be controlled.

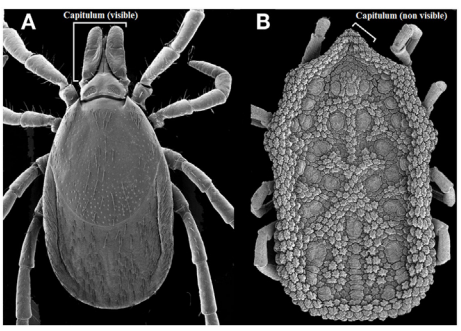

FIGURE 1

FIGURE 1

Main structural difference between hard **A**. and soft **B**. ticks. The figure displays the view of the back of the ticks. The main difference between hard and soft ticks is the visibility of the capitulum, which is visible in hard ticks and not visible in soft ticks.

FIGURE 2

The figure displays a cladogram with our current view on the relation between ticks, mosquitoes, spiders, and scorpions. The horizontal and vertical lines represent the evolutionary connections between these organisms, which shared a common ancestor in the past, ~700 MYA. The relation between these groups was taken from Jeyaprakash and Hoy [1].

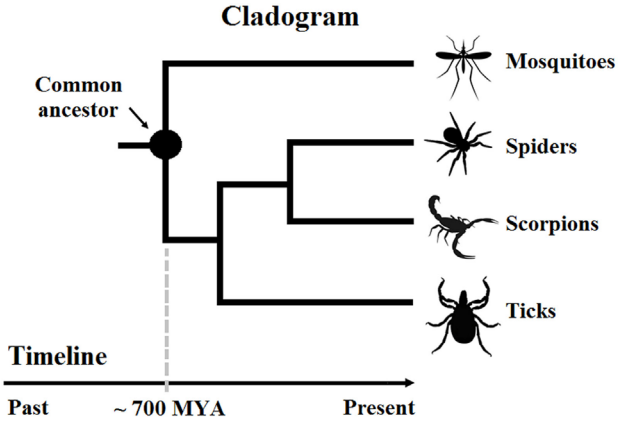

FIGURE 2

may ingest as much as 5–10 times their weight in blood in one feeding. After the female feeds on a host and mates, she drops to the ground and finds shelter in leaves or other natural material to lay thousands of eggs. Temperature controls egg development. The higher the temperature, the faster the eggs develop. There is an optimal temperature that varies among tick species, but 20°C is a good average temperature for egg development. Temperatures higher than 20°C increase the chance that the eggs will die. The immature tick that hatches out of the egg is called a larva. The larvae must then find a host. [Note: a tick's life cycle has three developmental stages after it hatches from the egg, the larva, the nymph, and the adult (male or female). You can see the tick developmental cycle in the video accompanying the recent publication by Kocan and coauthors [3].]

Ticks are not insects and cannot fly. They can only move long distances while feeding on a host, as the host moves around its environment. The smaller larvae and nymphs prefer to feed on small hosts such as rodents, birds, or lizards. Adult ticks need to ingest larger amounts of blood; therefore, they prefer to feed on large animals such as cattle, deer, horses, or humans. To find a host, *I. solitarius* climbs up onto vegetation, such as grass. This behavior is regulated by the weather. When the tick is on the vegetation waiting for a host, it is exposed to the sun and wind and loses water quickly. To rehydrate, the tick must go down to the ground again. If the humidity (amount of water in the air) is high, the tick may remain on the vegetation, waiting for a host, for longer periods of time.

Ticks are usually not picky about their hosts, so, while waiting on the vegetation, ticks attach to any suitable host that passes by. This is why humans are at risk when walking in the forest, or in the garden, without protection such as long socks or trousers. Once on the host, the tick will find a good place to feed and will insert its mouthparts to begin ingesting blood. The mouthparts of ticks include three main components known as hypostome, chelicera, and palps (Figure 3). While the hypostome and chelicera are completely inserted

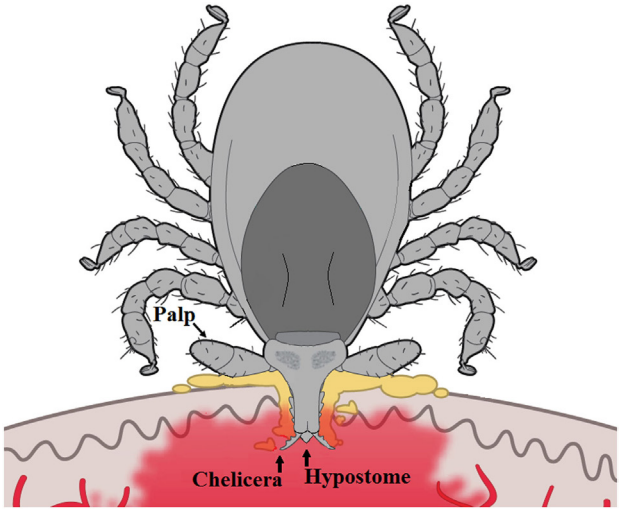

FIGURE 3

When feeding, ticks completely introduce the hypostome and chelicera in the skin. However, the palps remain outside of the feeding lesion.

in the skin of the host, the palps remain outside. The feeding process may take 3–4 days for the small larvae and nymphs and up to 10 days for the large females.

TICK SALIVA AS CAMOUFLAGE

Tick saliva is secreted by the salivary glands through the mouthparts. Substances in the tick's saliva help the tick to fight off the normal responses of the host, such as blood clotting and inflammation. One tick salivary substance that interferes with blood clotting is called **Kunitz peptide**. Kunitz peptides are small molecules that are also secreted by venomous organisms, such as scorpions and spiders, and they are an important component of tick saliva [4]. Tick salivary Kunitz peptides interfere with blood clotting, allowing the tick to slurp up its blood meal.

KUNITZ PEPTIDE

Small proteins (less than 60 amino acids) that usually inhibit degrading enzymes known as proteases.

Lipocalin is another tick salivary substance that interferes with inflammation. Have you ever been bitten by a mosquito? Does it hurt and leave a bump on the skin? Whenever you are cut, pricked, or bitten, your body usually responds by producing a substance called **histamine**, which causes inflammation. One tactic ticks use during blood feeding to prevent a host inflammatory response is to secrete lipocalins, which blocks the host's histamine. So, a tick bite does not cause a painful, itchy bump like a mosquito bite does.

LIPOCALIN

A protein family involved in transporting small, organic molecules.

HISTAMINE

An organic molecule naturally occurring in animals, usually involved in inflammation.

It is interesting to mention that these properties of tick saliva might be useful for medical purposes. Since Kunitz peptides interfere with blood clotting, they could be used, for example, in open heart surgery, when the doctors want to prevent blood clots from forming in the patient. Unwanted inflammatory responses include allergies and asthma; therefore, tick lipocalins that block histamine may be useful in treating these conditions.

WHEN TICKS BITE, THEY TRANSMIT INFECTIOUS DISEASES

PATHOGENS

Microorganisms that produce harm to humans and/or animals.

While feeding, *I. solitarius* can transmit different disease-causing organisms, called **pathogens**. These pathogens are mainly bacteria and viruses but can also be larger organisms called protozoa and helminths. Most tick-borne pathogens are transmitted in tick saliva. One exception is an organism called *Hepatozoon canis*, which is transmitted when an animal eats an infected tick. Diseases transmitted to humans by tick bites include Lyme disease, human granulocytic anaplasmosis, and tick-borne encephalitis. Lyme disease, caused by the bacterium *Borrelia burgdorferi*, is becoming more common, for example, about 300,000 Americans each year are infected with this disease. Typical symptoms of Lyme disease include fever, headache, fatigue, and a "bull's eye"-shaped skin rash. However, if untreated, Lyme disease can produce more severe symptoms and complications that include arthritis, neurologic symptoms, and heart problems. Human granulocytic anaplasmosis is caused by the bacteria *Anaplasma phagocytophilum*. The first symptoms of human granulocytic anaplasmosis typically begin within 1–2 weeks after the bite of an infected tick, and they include fever, headache, muscle pain, chills, nausea, abdominal pain, cough, and confusion. Finally, tick-borne encephalitis is caused by a virus, which directly attacks the brain and/or brain membranes (meninges). This is a common tick-borne disease in Europe, and at the beginning of the disease, the symptoms are non-specific and can be mistaken with the symptoms of other common diseases producing fever, headache, or vomiting. Later, as the disease progresses and the virus invades the brain, more specific symptoms appear including confusion, stiff neck, sensory disturbances, and/or paralysis.

GENOME

The entire DNA sequence of an organism that is found in the nucleus of the cells.

Although we still do not understand everything about how ticks interact with their hosts and their pathogens [5], advances in this field will be aided by the fact that the **genome** (the entire DNA sequence of an organism that is found in the nucleus of the cell) for one type of tick has been sequenced, or decoded. This tick is *Ixodes scapularis*, an important tick for transmitting both Lyme disease and human granulocytic anaplasmosis [6].

HOW TO AVOID TICK BITES

The best way to avoid tick bites is to stay away from ticks. Examples of how to avoid ticks can be found at the website of the Centers for Disease Control and Prevention (CDC).[1] About 80% of tick bites are reported between May and September, when ticks are very active. Therefore, more care should be taken when walking in woody and bushy areas during this period. Usually, strolling through the woods is more pleasurable during this period, so stay on the

[1] http://www.cdc.gov/ticks/avoid/on_people.html

path and walk in the center of the trails. Spraying insect repellents on clothes and exposed skin when going for walks in risky areas is also recommended. Repellents that contain substances called DEET (*N*,*N*-diethyl-m-toluamide) or permethrin will work to repel ticks. After any trip from woody and bushy areas, check your body closely in front of a mirror. *I. solitarius* nymphs can usually be found on the legs and arms, while adult ticks are found on the back, neck, head, groin, and genitals [7].

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I am a huge soccer fan and Pokemon enthusiast, hoping for a career in health-care engineering!

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