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Tick Literature Review

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CLINICAL BOTTOM LINE

- Ticks are important parasites, affecting both companion animals and humans.
- A variety of ticks exist in North America, but the ticks of importance to dogs and cats are from the family Ixodidae and are three-host ticks.
- Ticks present three main dangers to their hosts: the physical damage from the bite itself, other systemic effects of the tick's saliva and transmission of infectious diseases. Some of these diseases are zoonotic and of concern to humans.
- Physical removal of a tick using tweezers within 24 to 48 hours is thought to prevent most disease transmission.
- Prevention of tick infestation involves environmental management (such as erecting fences and cutting grass to reduce access to tick habitat) and application of chemicals to animals or the environment.

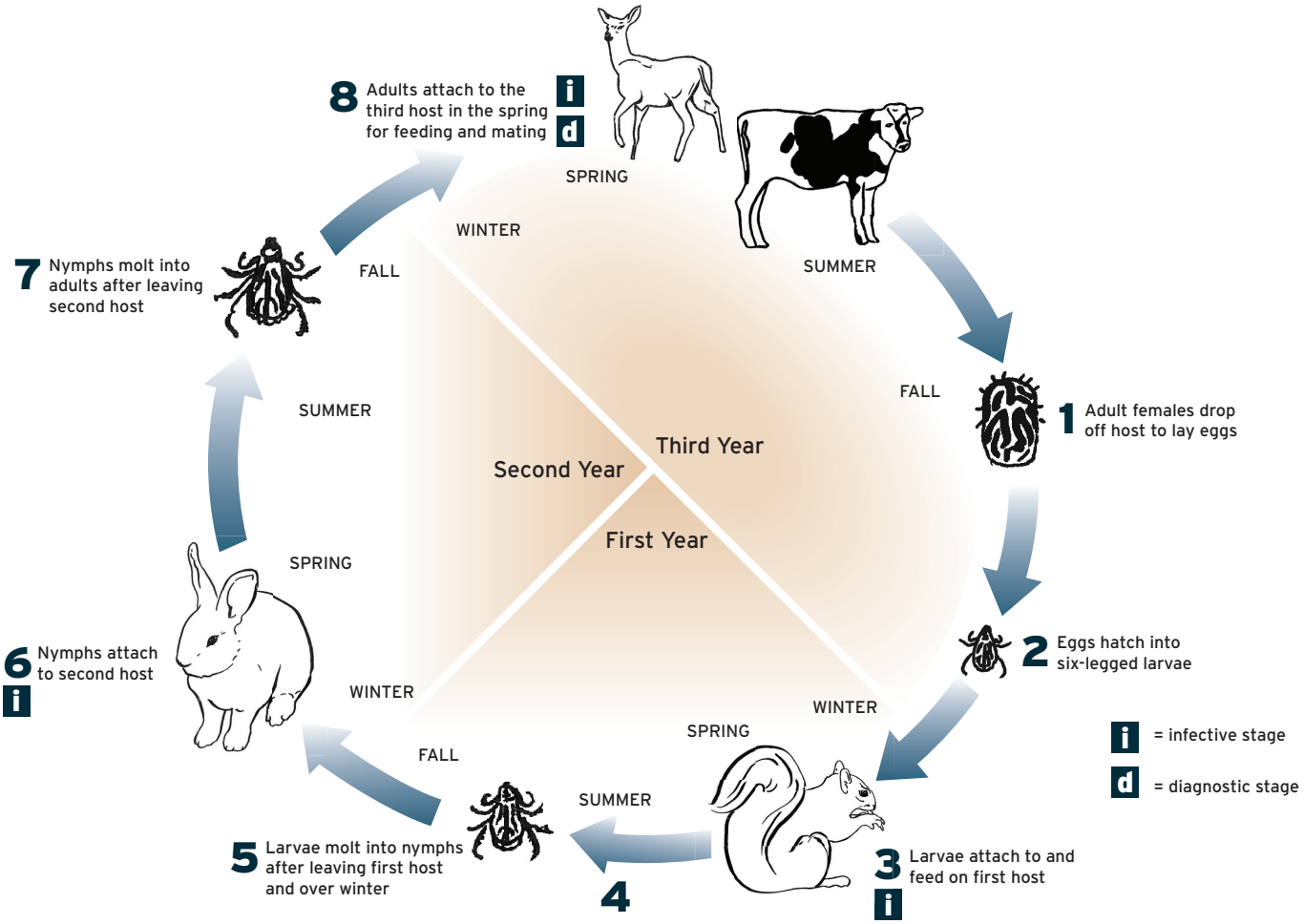
INTRODUCTION AND LIFE CYCLE

Ticks are obligate ectoparasites of mammals, reptiles and birds and are of medical and veterinary importance for a number of reasons.[1] The tick's bite causes discomfort and can lead to secondary infections, some species are capable of causing paralysis in animals and small children, and ticks are vectors of a number of diseases affecting both animals and humans.[2-4]

There are three families of ticks: the Argasidae, the Ixodidae and the Nuttalliellidae.[1] The Argasidae are known as "soft" ticks and the Ixodidae "hard" ticks, as the Ixodidae have a hard scutum, or shield, on their dorsal surface, whereas the Argasidae have a leathery cuticle.[5] The Nuttalliellidae have features which are intermediate between the other two families.[1] The Ixodidae can be further classified according to the number of hosts required to complete their life cycle from larva to nymph to adult (*Figure 1,* page 2). One-host ticks complete their life cycle on a single host; the larvae and nymphs of two-host ticks feed on one host, then the nymphs drop off to molt and the adult seeks a second host. With three-host ticks, the larvae and nymphs each drop off to molt and the subsequent stage seeks a new host. All of the tick species of importance to companion animals in North America are from the family Ixodidae and are three-host ticks, hence these will be the focus of this review. These ticks are: *Amblyomma americanum*, the Lone Star tick; *Dermacentor andersoni*, the Rocky Mountain wood tick; *Dermacentor variabilis*, the American dog tick; *Ixodes dammini*, the deer tick; *Ixodes pacificus*, the Western black-legged tick; and *Rhipicephalus sanguineus*, the brown dog tick. The hosts of these and other ticks are displayed in *Table 1,* page 3.

The principal feature that differentiates Ixodid ticks is the dorsal scutum, a hard plate that covers the entire dorsal surface of the male but only the anterior third of the dorsal surface of the female.[1,5] The Ixodid life cycle can take up to six years, however host attachment may constitute less than 2 percent of this time.[1] Starvation periods of more than three years are common, and these factors can add to the difficulty associated with environmental control of these parasites. Ixodid larvae have six legs, and the nymphs and adults each have eight legs.[1,5] The larvae, nymphs and adults each feed once before molting (larvae and nymphs), breeding (adult males) or laying eggs (adult females), and several days are required for complete engorgement.

Figure 1: Tick Life Cycle



Larvae hatch within days to months of the eggs being laid, depending on the environmental conditions. After finding a suitable host and feeding, the larva drops off and molts into a nymph. The nymph finds the next appropriate host and feeds for several days to a week. After engorging, the nymph drops off and molts to an adult, which must then find a third and final host. After the female tick has fed, she drops off the host and lays up to thousands of eggs in the environment over the following days or weeks, after which she dies.[1,6] Under ideal conditions, the cycle from egg to egg can be completed in a little over two months.

Ticks find their hosts by ambushing or active hunting. Ticks that employ a hunting strategy actively run or crawl toward their hosts. Ticks that employ an ambush strategy climb onto vegetation and wait for a host to pass by. Host recognition can be triggered by vibrations, smell, CO_2, heat and visual cues. The dorsal surface of the first pair of legs of ticks contains sensory organs, including the Haller's organ complex of receptors.[1] When a suitable host is detected, the tick adopts a "questing" posture, waving the first pair of legs in the air while it moves itself into a suitable position to crawl onto the host. If hosts are unavailable, unfed Ixodid adults can

Table 1: Species of Ticks*

TICK SPECIES	HOSTS	INFECTIOUS AGENTS/DISEASE TRANSMITTED OR PRODUCED Diseases affecting humans marked with (h)
Dermacentor variabilis	**Larvae**: Voles, mice **Nymphs**: Cats, dogs, opossums, rabbits, raccoons **Adults**: Cats, coyotes, dogs, cattle, horses, raccoons, other large mammals (including humans)	*Cytauxzoon felis, Francisella tularensis* (h), *Rickettsia rickettsii* (h), tick paralysis (h), *Ehrlichia chaffeensis* (h)
Dermacentor andersoni	**Larvae**: Voles, mice **Nymphs**: Cats, dogs, opossums, rabbits, raccoons **Adults**: Bears, coyotes, dogs, cattle, deer, horses, sheep, humans	*F tularensis* (h), *R rickettsii* (h), tick paralysis (h)
Amblyomma americanum	**Larvae and nymphs**: Bobwhite quail, turkey, wrens, numerous mammals such as cats, coyotes, white-tailed deer, dogs, red fox, rabbits, squirrels, raccoons, humans **Adults**: Cats, cattle, coyotes, white-tailed deer, dogs, horses, raccoons, sheep, humans	*Borrelia lonestari, E chaffeensis* (h), *Ehrlichia ewingii, F tularensis* (h), *Hepatozoon americanum*, tick paralysis
Amblyomma maculatum	**Larvae**: small rodents, ground-dwelling birds **Nymphs**: small rodents, ground-dwelling birds, dogs **Adults**: Horses, cattle, pigs, goats, dogs, bears, birds, bobcats, coyotes, rabbits, rodents, deer, humans	*H americanum*, *H canis*
Rhipicephalus sanguineus	**Larvae**: Dogs, rodents **Nymphs**: Dogs, rabbits **Adults**: Dogs	*Anaplasma platys, Babesia canis, Babesia gibsoni, Ehrlichia canis, Haemobartonella canis*
Ixodes scapularis	**Larvae**: Various rodents such as white-footed mice and shrews, other small mammals, birds, lizards **Nymphs**: Birds, cats, chipmunks, mice, opossums, raccoons, various rodents, skunks, shrews, squirrels, humans **Adults**: Bobcats, cattle, coyotes, dogs, foxes, white-tailed deer, opossums, raccoons, other wildlife	*Anaplasma phagocytophilum* (h), *Babesia microti* (h), *Borrelia burgdorferi* (h), tick paralysis (h)
Ixodes pacificus	**Larvae and Nymphs**: Lizards, small rodents, birds **Adults**: Large mammals (commonly deer), canids, horses, humans	*A phagocytophilum* (h), *E chaffeensis* (h), *B burgdorferi* (h), tick paralysis

*Adapted from Dryden and Payne, 2004, and Shaw, et al. 2001

survive for up to 14 years, and starvation periods of more than three years are common.[1] Once the tick has found a suitable host, it moves around to find a suitable feeding location. The first stage of feeding is attachment, whereby the tick uses the chelicerae (a component of the mouthparts) to cut through the skin, and then inserts the hypostome into the wound which anchors the tick with recurved teeth.[1] Some species of tick also secrete a cement-like substance from their salivary glands to help anchor them to the skin.[1,6] Tick salivary fluid has anticoagulant, vasodilatory, vascular permeability and cytolitic activity to varying degrees depending on the species of tick.[7] The next stage is the slow feeding phase, which takes about four to six days in most species, with minimal blood uptake in the first 12 to 24 hours.[1,6] During this phase, the female tick can grow to 10 times her unfed weight. The third and final stage is the rapid feeding phase, which occurs within about one to two days and during which the female can grow to 100 times her unfed weight.[1,6] Male ticks do not ingest as much blood as females.

PREVALENCE AND RISK FACTORS

Although the environmental characteristics of the habitat of various North American ticks have been described, there is little published data on population density or risk factors for infestation. Thus, risk factors for tick infestation depend largely on exposure to the tick's environment and the existence of favorable conditions for tick proliferation. For example, the peak activity of *Rhipicephalus sanguineus* in Europe occurs between 68°F to 86°F (20° to 30°C) at greater than 50 percent humidity.[8] In the Northern hemisphere, most ticks have bimodal peaks of activity in spring and summer.[9]

The prevalence of tick infestation in North America varies according to geographic location, as displayed in *Figure 2,* page 6.

CONSEQUENCES OF INFESTATION

Ticks present three main dangers to their hosts: the physical damage from the bite itself, other systemic effects of the tick's saliva and transmission of infectious diseases.

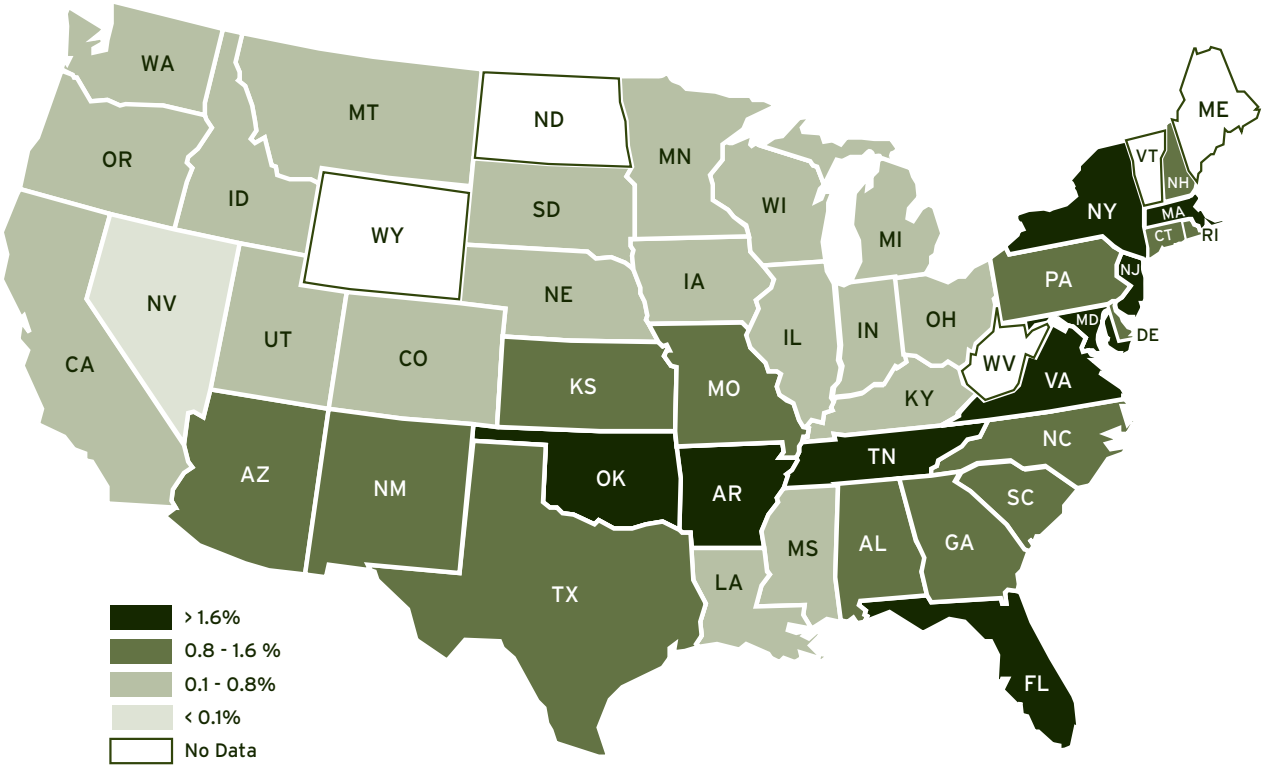
When ticks attach themselves to the host in the first stage of feeding, they cut the skin with their mouthparts and cause damage to tissues and capillaries.[1,6] Host reactions, such as mast cell degranulation leading to histamine release and inflammatory cell infiltration, further contribute to tissue damage. This tissue damage tends to be quite painful and may result in secondary bacterial infections. Ticks feed on the host's blood, and heavy infestations can also cause anemia.[1]

The systemic effects of a tick bite can be extremely serious. Many species of tick can cause debilitating or even fatal paralysis in their hosts.[1,5,10] The most potent cause of tick paralysis is *Ixodes holocyclus*, found along the east coast of Australia. In North America, *Ixodes pacificus*, *D variabilis*, and *D andersoni* have all been reported to cause tick paralysis in companion animals and humans, although paralysis is more commonly associated with *D andersoni* and *variabilis.*[1,5,10] *Amblyomma americanum* and *A maculatum* have also been reported to cause paralysis in companion animals.[5] The engorging adult female tick is usually responsible for paralysis. Ticks inject their saliva into the host while feeding, and paralysis is due to a protein present in the saliva.[1,7] Tick bites can also cause anaphylactic reactions in humans. These reactions have been reported sporadically in various locations around the world and are thought to be due to reactions to components of the tick's saliva.[11-13] To the author's knowledge, although anaphylaxis to tick antiserum is reasonably common, anaphylaxis to the tick bite itself has not been reported in companion animals. Ticks also transmit infectious diseases to both companion animals and humans, which include bacterial, rickettsial, spirochetal, protozoal and viral agents (*Table 2,* page 5).[14]

Table 2: Tick-borne Diseases

Agent Type	Agent	Vector	Clinical Syndrome/Comments
Bacterial	*Ehrlichia spp (E chaffeensis, E ewingii and E canis)* [4,6,14-17,18]	***E chaffeensis**: Dermacentor variabilis, Amblyomma americanum* and *Ixodes pacificus* ***E ewingii**: A americanum* ***E canis**: Rhipicephalus sanguineus*	***E canis***: Canine monocytic ehrlichiosis. Dogs are also susceptible to disease due to *E chaffeensis* and *E ewingii.* Tick acquisition of *E canis* from dogs treated with doxycycline has been documented.[18] ***E chaffeensis***: human monocytic ehrlichiosis ***E ewingii***: human granulocytic ehrlichiosis
	Francisella tularensis [1,5-6,14,19]	*D variabilis, D andersoni* and *A americanum*	Flu-like symptoms and lymphadenitis in humans. Cats can be infected with tularemia but do not usually show clinical signs despite extensive lesions in the lungs.
	Anaplasma phagocytophilum [4,6,15]	*Ixodes scapularis* and *Ixodes pacificus*	**Dogs**: fever and lethargy **Humans**: flu-like symptoms
	Haemobartonella canis [1,20]	*R sanguineus*	Anemia in splenectomized or immunosuppressed dogs
	Bartonella henselae [21]	Isolated from *Ixodes ricinus* (not present in North America)	Causative agent of cat scratch disease in humans. The significance of ticks as a vector of *B henselae* is yet to be determined.
Rickettsial	*Rickettsia rickettsii* [1,4-6,14,16,22]	*D variabilis* and *D andersoni*	Rocky Mountain Spotted Fever in humans, which begins as macules, then progresses to petechial a few days later. Causes a febrile illness with a wide variety of other clinical signs in dogs.
	Coxiella burnetii [5,14]	*D andersoni*	Subclinical disease in most animals and may cause a febrile illness in humans (Q fever), however most U.S. strains are avirulent.
Spirochetal	*Borrelia burgdorferi* [1,4,5,14,23,24]	Ticks of the genus Ixodes (*Ixodes scapularis* and *Ixodes pacificus* in North America)	**Dogs**: fever, lymphadenopathy and shifting lameness two to five months after infection **Humans**: biphasic disease. The early stage is known as Erythema chronicum migrans, with fever, lymphadenopathy and malaise. The later stage is arthritis, which may persist for years.
Protozoal	*Babesia spp (Babesia canis, B gibsoni and B microti)* [1,4,6,14]	***B canis** and **B gibsoni**: R sanguineus* ***B microti**: Ixodes scapularis*	**Dogs**: hemolytic anemia in dogs due to *B canis* or *B gibsoni* **Humans**: may be asymptomatic but can also cause a hemolytic anemia that may be lethal in splenectomized individuals.
	Hepatozoon americanum and H canis [6,25,26]	***H americanum** and **H canis**: A maculatum* ***H americanum**: A americanum*	**Dogs**: fever, weight loss and hyperesthesia over the paraspinal regions
	Cytauxzoon felis [6,26]	*D variabilis*	**Cats**: fever, depression, icterus and pale mucous membranes, may be fatal
Viral (North America only)	Colorado Tick Fever Virus (CTFV)[5,14]	*D andersoni*	**Humans**: brief flu-like illness

Figure 2: Tick Infestation Prevalence by State—Based on Banfield Data



These diseases can be transmitted by larvae, nymphs or adults, and infectious agents may even be passed intrastadially.[1,5] Intrastadial transmission occurs when a disease is acquired by one life-stage and carried through the molt to the subsequent life stage.

Some diseases may even be passed transovarially, from the adult female to the larvae via infection of the ovaries.[1,5]

TREATMENT AND PREVENTION

Ticks can be treated and/or prevented using both physical and chemical means. Physical means include manual removal of attached ticks and environmental modification to reduce the suitability of the habitat to ticks. Chemical treatment and prevention include products for use on companion animals and products for use in the environment.

Manual removal of ticks is usually performed as soon as an attached tick is found. It is generally accepted that removing or killing a tick within 24 to 48 hours of attachment will prevent disease transmission.[6] There have been few studies comparing the efficacy of different removal strategies, but the most effective means of removal seems to be direct manual removal without twisting.[27,28] The few studies examining various removal strategies have shown that fingernail polish, petroleum jelly, 70 percent isopropyl alcohol, a glowing hot match, or gasoline are not effective and that rotation while twisting is more likely to lead to retained mouthparts.[27,28] To remove a tick, grasp the head of the tick with fine-point tweezers as close to the skin as possible. Avoid squeezing the body and apply gentle traction to pull the tick straight out; this should minimize the chances of leaving mouthparts behind.[10,27,28]

Table 3: Chemicals Used for Treatment and Control of Tick Infestation

Agent (class)	Mode of Action	Description	Contraindications/Comments
Amitraz[28,29]	Not well understood. It is a monoamine oxidase inhibitor in mites and may have CNS effects in susceptible organisms.	Usually used for treatment of demodicosis, but also used for prevention of tick infestation when used in a different formulation to the mite treatment product.	Do not use in cats, rabbits or in dogs under 4 months of age. Caution should be exercised when using amitraz in diabetic patients, and humans with diabetes should not handle it.
Diazinon[5, 30]	Organophosphate insecticide	Used for the control of a wide variety of insects.	If used for tick control, it should be applied by a pest control professional.
Fipronil[29]	Interferes with the passage of chloride ions in GABA channels, disrupting CNS activity.	Phenylpyrazole antiparasitic	Do not use on puppies or kittens less than 8 weeks of age. Contraindicated in rabbits. Do not bathe within 48 hours of application.
Permethrin[5, 28,29]	Affects sodium channels in nerves, leading to repeated nerve depolarization, paralysis and death.	Synthetic analogues of pyrethrins. More stable but slightly more toxic.	Should not be used in cats, may cause contact dermatitis in humans.
Selamectin[28-29]	Enhances chloride permeability or release of GABA at presynaptic neurons causing paralysis of the parasite.	Avermectin antiparasitic	Use with caution in sick, underweight or debilitated dogs and cats or avermectin-sensitive Collies. Not recommended for use in dogs and cats under 6 weeks of age.

Prevention of tick infestation through environmental control involves identifying areas where ticks may proliferate or ambush people or companion animals, and taking appropriate measures to prevent tick proliferation or interaction. This may include mowing or cutting grass and brush, erecting fences to prevent contact with these areas or use of environmental pesticides (*Table 3*).[6,10] Indoor or outdoor application of acaricides is best performed by a licensed pest exterminator.

CONCLUSIONS

Ticks are common ectoparasites of both companion animals and humans. They have the potential to cause harm in a number of ways—from the physical effects of their bite, paralysis or (rarely) anaphylactic reactions, to their saliva, to the numerous diseases they are able to transmit. The risk of tick infestation and subsequent disease varies greatly according to geographic location, activity and behaviors of owners and their Pets and preventive strategies that owners employ. Effective tick control depends on knowledge of the ticks present in the local area, regular monitoring for ticks if the location or activities increase risk of infestation, and proactive use of preventive strategies, such as environmental control and application of chemical preventives.

ABOUT THE AUTHOR

Patrick Shearer, BVMS, PhD, graduated from Murdoch University School of Veterinary and Biomedical Sciences in Perth, Western Australia. Dr. Shearer joined the Banfield Applied Research and Knowledge (BARK) team as an associate medical advisor in 2009.

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