***Bothriocroton* (includes some *Aponomma*)**
(arachnid: tick)

Overview

Arthropods are coelomate metameric invertebrate animals with a chitinous exoskeleton and jointed limbs. They undergo protostomial embryonic development and grow by cuticular moulting (ecdysis). Three main subphyla are recognized: Chelicerata, Crustacea and Hexapoda. Arachnids have chelicerate mouthparts, two tagmata (cephalothorax and abdomen), four pairs of legs and slit sensilla, but no antennae or wings. All species exhibit incomplete metamorphosis whereby eggs hatch larvae which moult to nymphs and then adults. Acarines comprise the ticks and mites which have sac-like bodies with inconspicuous segmentation and their mouthparts are confined to an anterior capitulum. Four major groups are recognized primarily on the location of their respiratory stigmata: ixodid ticks (Metastigmata), gamesid mites (Mesostigmata), trombidiform mites (Prostigmata) and sarcoptiform mites (Astigmata). Ticks have respiratory stigmata posterior to their legs. They are obligate blood-feeding ectoparasites on vertebrate hosts and their hypostomes are toothed and exposed. Two families are recognized: Argasidae and Ixodidae, known as soft and hard ticks, respectively. Ixodids have hard bodies with a dorsal scutum (shield-shaped plate) and the capitulum is not covered by the body. Larvae, nymphs and adults attach and feed on host blood, their life-cycles involving one, two or three hosts depending on whether moulting occurs on or off the host. Some 650 species of hard ticks infest mammals, birds and reptiles. Infestations by *Bothriocroton* (established for various *Aponomma* spp.) occur as three-host ticks mainly on reptiles, but including some Australian marsupials.

Classification:

Domain:	Eukaryota (membrane-bound nucleus)
Supergroup:	Amorphea (unikonts with single flagellum, or nonflagellated amoebae)
Kingdom:	Metazoa (multicellular eukaryotes, heterotrophs, notably animals)
Group:	Protostomia (triploblastic, spiral cleavage)
Subgroup:	Ecdysozoa (cuticle moulted = ecdysis)
Phylum:	Arthropoda (chitinous exoskeleton, segmented body, jointed limbs, haemocoel)
Subphylum:	Chelicerata (chelicerate mouthparts, two tagmata, no antennae)
Class:	Arachnida (spiders & allies, four pairs of legs, slit sensilla, incomplete metamorphosis)
Subclass:	Acari (Acarina) (ticks and mites, segmentation inconspicuous, sac-like body, mouthparts on capitulum)
Superorder:	Parasitiformes (ticks and some mites, with posterior stigmata)
Order:	Ixodida (Metastigmata) (ticks, macroscopic, stigmata posterior to legs, hypostome toothed, ectoparasites)
Family:	Ixodidae (hard ticks, with dorsal scutum, capitulum projects anteriorly, attach and feed on 1, 2 or 3 hosts)
Genus:	*Bothriocroton* (syn. *Aponomma p.p.*) (parasitic on skin of reptiles/mammals)
Species:	various species may cause skin lesions

Parasite biodiversity and host range: Most Metazoa are multicellular triploblastic animals with differentiated tissues, many being bilaterally symmetrical with a body cavity. Most invertebrate animals are protostomes as their embryonic development involves spiral determinate cleavage. Those that moult their external cuticles during their life-cycles (process known as ecdysis) are grouped together in the unique clade Ecdysozoa, including the nematodes (roundworms), onychophorans (velvet worms), tardigrades (water bears) and arthropods (myriapods, chelicerates, crustaceans and hexapods). Arthropods have small segmented bodies encased in chitinous exoskeletons with articulated limbs. Most species are free-living in terrestrial and aquatic habitats, although a small range are ectoparasitic on other animals, some feeding on the blood or skin of vertebrates. Five subphyla are recognized: Chelicerata, Crustacea, Hexapoda, Myriapoda and Trilobita. The chelicerates typically have appendages (chelicerae) in the form of pincers or fangs anterior to the mouthparts, 2 body parts (cephalothorax and abdomen), but no antennae or wings. Three classes are recognized: Arachnida (spiders and allies), Merostomata (horseshoe crabs) and Pycnogonida (sea spiders). Arachnids have 8 legs, slit sensilla and life-cycles involving incomplete metamorphosis whereby larvae and nymphs resemble adults. They are classified in 4 orders: Acari (acarines), Araneae (spiders), Opiliones (harvestmen) and Scorpiones (scorpions). The Acari comprises the ticks and mites which have saccular bodies and mouthparts confined to an anterior capitulum. Four major groups are recognized primarily on the location of their respiratory stigmata (called spiracles in insects): ixodid ticks (posterior Metastigmata), gamesid mites (middle Mesostigmata), trombidiform mites (anterior Prostigmata) and sarcoptiform mites (without stigmata = Astigmata).

Major parasitic families	Biodiversity	Hosts	Parasitic stages	Pathogenesis	Disease transmission
Superorder: Parasitiformes (ticks and some mites, with posterior stigmata)					
Order: Ixodida [Metastigmata] (ticks, macroscopic, stigmata posterior to legs) [3 families]					
Argasidae (soft ticks)	5 genera, 193 species	birds, mammals	larvae, nymphs, adults	blood-sucking	viral, bacterial
Ixodidae (hard ticks)	14 genera, 705 species	birds, mammals	larvae, nymphs, adults	blood-sucking, paralysis	viral, bacterial, protozoal
Order: Mesostigmata [Gamasida] (gamesid mites, stigmata between 2nd & 4th legs) [100 families, 662 genera, 5,360 species]					
Macronyssidae (sucking mites)	26 genera, 127 species	birds, reptiles, mammals	nymphs, adults	blood-sucking	bacterial
Dermanyssidae (sucking mites)	5 genera, 37 species	birds, mammals	nymphs, adults	blood-sucking	viral, bacterial
Halarachnidae (lung/ear mites)	7 genera, 10 species	mammals	nymphs, adults	mucosal erosion	-
Raillietiidae (ear mites)	1 genus, 7 species	mammals	nymphs, adults	ear wax	-
Rhinonyssidae (nasal mites)	30 genera, 160 species	birds	nymphs, adults	inflammation	-
Varroidae (bee mites)	1 genus, 5 species	bees	nymphs, adults	haemolymph-feeding	viral
Superorder: Acariformes (diverse group of mites, without posterior stigmata) [351 families, 32,000 species]					
Order: Prostigmata [Trombidiformes, Actinedida] (sucking mites, stigmata on capitulum) [34 superfamilies]					
Demodecidae (follicle mites)	7 genera, 65 species	mammals	larvae, nymphs, adults	inflammation	-
Cheyletidae (fur mites)	80 genera, 500 species	mammals (dogs, cats, rabbits), birds	larvae, nymphs, adults	pruritus	-
Myobiidae (fur mites)	46 genera, 185 species	mammals (rodents, bats, marsupials)	larvae, nymphs, adults	mange	-
Psorergatidae (itch mites)	3 genera, 77 species	mammals (rodents, artiodactyls)	larvae, nymphs, adults	mange	-
Trombiculidae (chigger mites)	71 genera, 3,000 species	mammals, birds	larvae	skin-feeding	bacterial
Order: Astigmata [Sarcoptiformes, Acaridida] (fur/feather/itch/dust mites, lacking stigmata) [230 families, 15,000 species]					
Sarcoptidae (itch mites)	3 genera, 42 spp./ssp.	mammals	larvae, nymphs, adults	scabies, mange	-
Psoroptidae (scab mites)	20 genera, species	mammals (carnivores, ungulates)	larvae, nymphs, adults	mange	-
Listrophoridae (fur mites)	20 genera, 170 species	mammals (esp. rodents)	larvae, nymphs, adults	mange	-
Myocoptidae (fur mites)	10 genera, 70 species	mammals (esp. rodents)	larvae, nymphs, adults	myocoptic mange	-
Cytoditidae (airsac/nasal mites)	2 genera, 12 species	birds	larvae, nymphs, adults	respiratory signs	-
Knemidokoptidae (burrowing mites)	7 genera, 16 species	birds	larvae, nymphs, adults	scaly face, scaly leg	-
Laminosioptidae (quill/skin mites)	8 genera, 25 species	birds	larvae, nymphs, adults	flesh/skin lesions	-

The superorder Parasitiformes comprises acarines with posterior respiratory stigmata and includes two major orders: the ixodid ticks (order Metastigmata) with stigmata located posterior to the legs (behind coxae III or IV); and the gamesid mites (order Mesostigmata) where they are located between the legs, sometimes associated with sinuous processes (peritremes). Ticks are further characterized by macroscopic bodies with an exposed ventral hypostome (toothed with backwardly-directed barbs), chelicerae with only 2 joints, long legs with free articulated coxae (not fused to the body wall) and a complex sensory pit (Haller's organ) on tarsus I. They are obligate blood-sucking parasites which feed on terrestrial vertebrates (mammals, birds, reptiles and some amphibians) as larvae, nymphs and adults with 1-, 2- or 3-host life-cycles. Almost 1,000 species have been classified within some 20 genera from numerous wild and domesticated animals around the world. Two main families are recognized: the Argasidae containing ~200 species of 'soft' ticks with flexible leathery cuticles, ventral capitula, short feeding times (< 1 hour) and long life-spans (up to 20 years); and the Ixodidae containing ~800 species of 'hard' ticks with rigid dorsal scutal plates, anterior capitula, long feeding times (hours to days) and shorter life-span (2-6 years). Basic characteristics of representative genera considered in this resource are tabulated below.

Genus	Capitulum				Idiosoma				Usual no. of hosts
	location	basis capitulum	mouth-parts	palps	integument	festoons	eyes	male ventral plates	
Argasidae (soft ticks with leathery cuticle, stigmata between coxae III)									
Argas	ventral	triangular	short	leg-like	stippled with lateral suture	absent	absent	absent	>3
Ornithodorus	ventral	rectangular	short	leg-like	mamillated	absent	usually absent	absent	>3
Otobius	ventral	rectangular	short	leg-like	spinose (nymphs), granulated (adult)	absent	absent	absent	1
Ixodidae (hard ticks with sclerotized dorsal plate (scutum), stigmata behind coxae IV)									
Prostriata (anal groove anterior)									
Ixodes	anterior	triangular	long	long	inornate	absent	absent	present	3
Metastriata (anal groove posterior)									
Amblyomma	anterior	rectangular	long	long	ornate	present	present	indistinct	3
(*Aponomma*)	anterior	rectangular	long	long	often ornate	present	absent	absent	3
Rhipicephalus	anterior	hexagonal	short	medium	some ornate	present	present	present	3
(*Boophilus*)	anterior	hexagonal	short	short	inornate	absent	present	present	1
Dermacentor	anterior	rectangular	short	medium	often ornate	present	present	absent	3
Haemaphysalis	anterior	rectangular	short	short	inornate	present	absent	absent	3
Hyalomma	anterior	rectangular	long	long	inornate	present	present	present	2
Bothriocroton	anterior	pentagonal	long	long	ornate	present	absent	absent	3

The family Ixodidae contains 6 subfamilies (Amblyomminae, Bothriocrotoninae, Haemaphysalinae, Hyalomminae, Ixodinae and Rhipicephalinae) which vary in their morphology, biology, host ranges and specificity. [Note that some taxonomic authorities have merged the subfamilies Rhipicephalinae and Hyalomminae, while others have subsequently assigned the subfamilies Amblyomminae and Rhipicephalinae into the new family Amblyommidae, predominantly on the basis of molecular phylogenetic studies]. Hard ticks had previously been divided into 2 groups: the Prostriata (with the anal groove anterior to the anus) and the Metastriata (anal groove absent or posterior to anus). The Prostriata essentially comprises the subfamily Ixodinae with over 230 species assigned to the single extant genus *Ixodes* [plus one fossil genus (*Cornupalpatum*)], while the Metastriata contains members of the remaining subfamilies with over 600 species classified into 18 genera. The subfamily Bothriocrotoninae comprises metastriate ornate ticks with festoons but lacking eyes and ventral shields. The subfamily is monotypic and only contains one genus, namely *Bothriocroton* [this genus is essentially a partial synonym of the defunct genus *Aponomma* as it was erected on the basis of molecular studies to accommodate several Australian *Aponomma* spp., while the remaining *Aponomma* spp. were transferred to the genus *Amblyomma*]. A small number of *Bothriocroton* spp. are recognized as ectoparasites feeding not only on varanid lizards but also on some Australian marsupials (wombat and echidna). They are relatively large ticks with long palps and an ornate scutum with posterior festoons but lacking eyes. Recent molecular screening studies have detected rickettsial bacteria in several species, possibly involved in the transmission of Flinders Island spotted fever.

***Bothriocroton* species**	**Hosts**	**Clinical signs**	**Distribution**
B. auruginans (syn. *Aponomma*)	Diprotodontia: vombatid (common wombat, hairy-nosed wombat); Carnivora: canid (dog), felid (cat); Primates: hominid (human) (3-host cycle)	trauma, irritation	Australia
B. concolor (syn. *Aponomma concolor, tropicum*)	Monotremata: tachyglossid (short-beaked echidna); plus doubtful records on Peramelemorphia: peramelid (bandicoot), Artiodactyla: bovid (cattle); Perissodactyla: equid (horse) (3-host cycle)	trauma, irritation	Australia
B. glebopalma (syn. *Aponomma*)	Squamata: varanid (twilight monitor, Kimberley rock monitor)		Australia
B. hydrosauri (syn. *Amblyomma*, *Ixodes, Aponomma trachysauri*) (southern reptile tick)	Artiodactyla: bovid (cattle); Perissodactyla: equid (horse); Peramelemorphia: peramelid (long-nosed bandicoot); Monotremata: tachyglossid (short-beaked echidna); Rodentia: murid (mouse); Primates: hominid (human); Sauria: agamid (eastern bearded dragon, central bearded dragon, mountain heath dragon, superb two-line dragon), scincid (metallic skink, White's skink, southern blue-		Australia

	tongued lizard, western blue-tongued lizard, common blue-tongued skink, pygmy blue-tongued lizard, blotched blue-tongue lizard, sleepy lizard), varanid (sand goanna, lace monitor); Serpentes: elapid (common death adder, lowland copperhead, Australian copperhead, eastern brown snake, white-lipped snake, mainland tiger snake, peninsula black tiger snake); Testudines: chelid (eastern long-necked tortoise)		
B. oudemansi (syn. *Aponomma*)	Monotremata: tachyglossid (long-beaked echidna, short-beaked echidna)		New Guinea
B. tachyglossi (syn. *Aponomma*)	Monotremata: tachyglossid (short-beaked echidna); Artiodactyla: bovid (cattle)		Australia
B. undatum (syn. *Aponomma, B. decorosum, I. decorosus*) (goanna tick)	Monotremata: tachyglossid (short-beaked echidna); Sauria: scincid (common blue-tongued skink), varanid (sand goanna, lace monitor, perentie, Dampier Peninsula monitor, Asian water monitor); Serpentes: pythonid (carpet python, Darwin carpet python)		Australia

Parasite morphology: Like other ticks, *Bothriocroton* spp. form 4 different types of morphological developmental stages: namely, eggs, larvae, nymphs and adults. The eggs are small brown ovoid stages measuring 0.4-0.5 mm in diameter and generally occur in small clusters. Larvae are dorsoventrally flattened stages that are oval-pyriform in dorsal profile measuring 0.5-1.0 mm long. The idiosoma (body) has a dorsal plate (scutum) and is often brown in colour with pale margins and posterior festoons. The ventral surface gives rise to 3 pairs of long pale legs. The anterior capitulum (head) projects forwards and has long palps and mouthparts. Larvae lack respiratory stigmata and do not have a groove around the anus. Nymphs are similar in shape but larger in size, measuring 1.0-2.5 mm and having slightly darker bodies. The idiosoma has a dorsal scutum, posterior festoons, lateral respiratory stigmata, a ventral anus with a posterior anal groove and 4 pairs of long ventral legs. The anterior capitulum has a subrectangular basis capitulum supporting long palps and mouthparts. Adult ticks vary considerably in size and shape depending on their gender and feeding status. Unfed males and females have a flat ventrum, slightly convex dorsum and are oval-pyriform in outline (males measuring 2-5 mm long, females 3-7 mm). They become more convex when feeding, with engorging females swelling markedly to become large ovoid-ellipsoid globular stages measuring up to 15-20 mm in length. Adults range in colour from pale cream to yellow-brown to red-brown, with males appearing darker and engorged females appearing lighter, sometimes even grey-blue. The anterior capitulum is visible from above (while that of argasids is ventral and not visible from above) and consists of a basis capitulum (integumental ring encircling mouthparts) and gnathosoma containing the mouthparts (palps, chelicerae and hypostome), but lacks antennae. The basis capitulum is pentagonal (not triangular, rectangular or hexagonal like other ixodids) and the dorsal surface bears a pair of porose areas (clusters of pores) that are involved in waterproofing eggs. The 2 sensory palps are long and have unequal segments (long segment 2, short segment 3), all of which move laterally during feeding and do not enter the skin. The mouthparts are also long and have a central barbed hypostome flanked by 2 chelicerae with tubular shafts and terminal digits with recurved denticles. The chelicerae cut the skin allowing the hypostome to be inserted into pooling blood. A feeding tube (buccal canal) is formed dorsally by the chelicerae and ventrally by the hypostome allowing blood to be ingested and saliva to be injected from long saccular salivary glands. Blood is sucked up by a muscular pharynx into a short tubular oesophagus and delivered to the digestive midgut (ventriculus) with several pairs of lateral diverticula (caeca). Waste material from the midgut and excretory Malpighian tubules is collected into a rectal sac and voided through a ventral subterminal anus. Externally, the anus has a posterior (metastriate) anal groove (while Ixodes has an anterior (prostriate) anal groove). The idiosoma bears a sclerotized dorsal scutum which occupies most of dorsal surface in males (= conscutum) but appears as smaller shield in females). It is often ornate and has irregular pale enamel markings, white in some species and pitted in others. The posterior body margin bears a series of regular festoons, often with pale edges imparting a dentate appearance. *Bothriocroton* spp. do not possess lateral eyes on the scutum, nor do all other former *Aponomma* spp. transferred to the genus *Amblyomma.* The anteroventral body is the point of attachment for 4 pairs of long jointed legs, usually lighter in colour and ornamented with conspicuous pale rings or bands. Each leg has 6 segments (coxa, trochanter, femur, patella (genu), tibia, and tarsus) and terminates in a pair of claws with a pad-like pulvillus. The coxae have 2 spurs, the trochanters have single subterminal spurs and the tarsi on the forelegs have a unique sensory structure (Haller's organ) used to detect odours and vibrations. Adults have a pair of lateral respiratory stigmata surrounded by oval plates located behind coxae IV (while argasids have small stigmata between coxae III). Adult male ticks do not have ventral adanal or accessory plates or plaques (which are present in *Ixodes*, *Rhipicephalus*/*Boophilus*, *Hyalomma* and eyed *Amblyomma*). Mature males have paired tubular testes with vas efferentia fusing to form a common vas deferens (with a lobular accessory gland) leading to the ejaculatory duct and genital aperture (gonopore) opening mid-ventrally with an anterior sclerotized flap (genital apron). Copulation involves the transfer of packets of spermatids (spermatophores) to the genital operculum of females. Mature females have a single saccular ovary with paired tubular oviducts joined to a common uterus (with accessory glands) and bipartite vagina (with a cervical region that acts as a receptaculum seminis to store spermatophores, and a vestibular region that prolapses during oviposition). The genital aperture is U-shaped and located on the ventral midbody behind an anterior genital apron. Eggs are coated with waxy waterproofing secretions from a special gland (Gene’s organ) located near the capitulum-idiosoma as well as from porose areas on the basis capitulum.

Site of infection: All motile developmental stages (larvae, nymphs and adults) are ectoparasitic on native Australian animals, particularly reptiles but also including mammals. Infestations have been recorded on reptiles belonging to 3 lizard families, 2 snake families and one tortoise family, as well as on mammals belonging to 9 families in 8 orders (notably marsupials (esp. wombats), monotremes (esp. echidnas), some carnivores, ungulates, rodents, and occasionally humans). Seven species with variable host ranges are recognized, several being confined to small host groups but others having broad host specificities (or host preferences) for both reptilian and mammalian hosts. Ticks also exhibit some site specificity and attach to hosts in regions that are difficult to groom, such as around the head (including the ears and nostrils), the back of the neck and the axillae of the forelegs. They are generally found in skin folds or under scales depending on the host species.

Pathogenesis: Larvae, nymphs and adult ticks are obligate haematophagous parasites that must feed on host blood for several days in order to develop further. They use their cutting/sucking mouthparts to lacerate the skin creating pools of blood into which they insert their hypostomes to ingest blood (feeding process known as telmophagy). During feeding, they inject saliva containing numerous vaso-active compounds (with analgesic, anticoagulatory and vasodilatory properties) as well as a proteinaceous cement to secure their attachment and form a closed feeding lesion. Tick bites cause local tissue trauma with irritation, inflammation, erythema, oedema, pruritus, focal necrosis and granuloma formation. Reptiles may harbour a few or many feeding stages, often clustered together and sometimes without apparent ill effect. Heavy infestations may develop on burrowing animals (wombats and echidnas) producing granulomatous lesions with ill-health and haematological perturbations associated with numerous engorging females. Infestations on pets (cats and dogs) generally involve larvae and nymphs particularly around the faces of animals visiting wombat burrows. Infestations on livestock and humans appear incidental and may cause localized lesions with inflammation and variable pruritus. Epidemiological and experimental studies have shown that these ticks may act as transmission vectors for several infectious microbial diseases. *B. hydrosauri* appears to be vector for rickettsial bacteria causing Flinders Island spotted fever in humans and proteobacteria causing coxiellosis (Q fever) in ungulates. Molecular screening studies have recently detected several spirochaete bacteria (*Borrelia* spp.) in echidna ticks (*B. concolor*), but their involvement in any disease transmission is unknown.

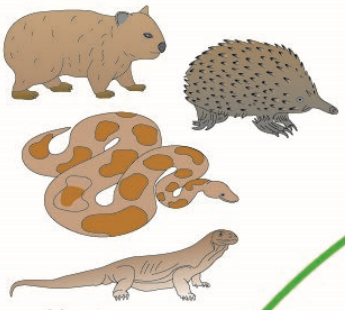
Developmental cycle and mode of transmission: *Bothriocroton* spp. have life-cycles involving incomplete (hemimetabolous) metamorphosis whereby eggs hatch larvae which moult to nymphs and then adults. Studies on several species have shown that they have 3-host life-cycles, with each developmental stage feeding once to repletion on a separate host. However, each stage infests the same range of hosts, so all stages may sometimes be present on the same individual host. Gravid females lay eggs on the ground where they hatch after 25-70 days depending on prevailing conditions (faster in warmer conditions). The emergent larvae aggregate at the soil-litter interface, a behaviour thought to be aided by the release of aggregation pheromones. Larvae are susceptible to desiccation so they seek locations with stable microclimates (without temperature extremes or low humidity), often aggregating in burrows, refuges or hides used by animals. Here they quest for hosts (ambush strategy) using sensory structures to detect odours and vibrations associated with passing hosts. They have been shown to quest for up to 200 days in cold conditions but with high humidity. Having located a host, they crawl onto the skin and attach at preferred sites to feed on blood. They feed to repletion over several days (occasionally up to 30 days) before dropping off into the external environment, usually the next time the host enters its shelter. They then enter a pre-moult period lasting 15-24 days to digest their bloodmeals before moulting to nymphs (only one nymphal instar is formed, whereas argasids may form 2-7 instars). Nymphs also aggregate low in leaf litter and appear to be more susceptible to desiccation than larvae. They quest for hosts over several weeks and only disperse from aggregation sites when hosts are detected nearby (within 20-50 cm). Nymphs crawl onto the skin of hosts brushing past and move to preferred sites to attach and feed on blood for several days (some feeding for up to 23 days). When replete they detach and drop from the host onto the ground, again in the vicinity of animal refuges. Nymphs enter a shorter pre-moult period lasting around one week before moulting to adult ticks (both males and females). Adults shelter in litter and vegetation while questing for passing hosts and have been shown to survive unfed for up to 100 days. Having located a host, the adults crawl onto the skin to attach and feed (both sexes requiring a bloodmeal to become sexually mature). Mating occurs on hosts when feeding females emit an air-borne excitant pheromone which induces feeding males to detach and search for sexually receptive females. If males are not activated, they may remain attached for months, feeding sparingly and waiting for mating opportunities. Once mated, females are not subsequently approached by males but continue feeding to massive engorgement over 1-2 weeks. They then detach and drop off the host, again in the vicinity of animal shelters. They enter a pre-oviposition period lasting up to one month (longer in colder conditions) and then begin laying large batches of several thousand eggs (1,500-2,000) over several weeks (up to 40 days) before becoming spent and dying. The whole life-cycle is usually completed in 18 months but may vary according to climatic conditions (longer in colder conditions) and the host abundance (longer when hosts are scarce).

Differential diagnosis: The incidental detection of bite sites and skin lesions on animals is not pathognomonic as many aetiological agents may be involved, including other ectoparasites. Infestations are typically diagnosed by the direct observation of feeding or engorged ticks attached to hosts. Specimens may be carefully removed for microscopic examination and identification by their morphological characteristics (namely, ornate eyeless bodies with festoons, long palps and mouthparts, pentagonal basis capituli, and males lacking ventral plates). Molecular biological techniques have been used to characterize species and reconstruct phylogenies following the polymerase chain reaction (PCR) amplification of nuclear (18S and 28S ribosomal RNA, internal transcribed spacer regions 1 and 2) and mitochondrial (12S and 16S ribosomal RNA, cytochrome c oxidase subunit I, nicotinamide adenine dinucleotide dehydrogenase subunit 5) gene sequences. Comparative molecular characterization studies were instrumental

in the creation of the genus *Bothriocroton* to accommodate several former *Aponomma* spp. from Australian animals, while the remaining *Aponomma* spp. were transferred to the genus *Amblyomma* (often referred to as eyeless *Amblyomma*).

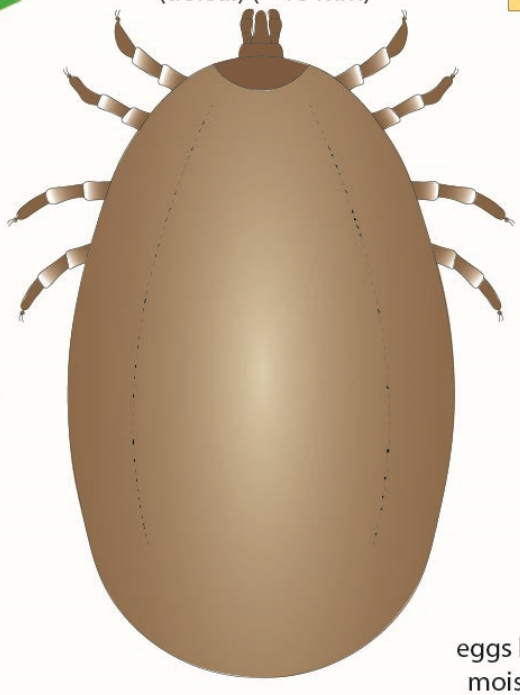
Treatment and control: Infestations vary significantly in their intensity with many hosts (reptiles and mammals) having few ticks but some individuals developing heavy infestations (particularly wombats and some larger lizards). Although infestations may be regarded as transient and not requiring treatment (because feeding stages eventually drop off of their own accord when replete), medical or veterinary interventions may be required in cases involving large numbers of ticks (especially different stages at different periods of development), in hosts developing severe clinical signs (including small animals infested by several large engorged females) and even for cosmetic purposes in animals kept for display in vivaria (such as zoological collections and wildlife parks). Individual ticks may be removed by carefully pulling them off with tweezers, forceps or special tick removal tools. Physical removal may cause some temporary minor bleeding, but caution is advised as squeezing or tearing ticks may increase the risk of systemic reactions and anaphylaxis due to the release of allergenic compounds. Similarly, care should be exercised using folklore remedies that involve freezing ticks or applying oils, solvents or volatile fluids to their backs as they may release pro-inflammatory compounds before detaching or dying. Infestations are best treated using acaricidal chemicals which may be applied as sprays, emulsions, dusts, pour-ons, drenches, tablets or injections, but attention should be paid to any contra-indications as some formulations have toxic or adverse side-effects in certain host species. Treatments have organochlorines (dichloro-diphenyl-trichloroethane (DDT), lindane), organophosphates (dichlorvos, coumaphos, malathion, diazinon, trichlorfon), carbamates (carbaryl), pyrethroids (permethrin, deltamethrin, cypermethrin) and more recently, formamidines (amitraz), macrocyclic lactones (ivermectin, selamectin), phenylpyrazoles (fipronil), chloronicotinyls (imidacloprid) and isoxazolines (afoxolaner, fluralaner). There are growing concerns over the development of drug resistance in other tick genera, particularly to organochlorines, organophosphates, pyrethroids and formamidines, so it is recommended that acaricides belonging to different chemical classes be used in cyclic rotation or as combination cocktails. People at rick may also use personal protection by applying repellents (such as diethyltoluamide (DEET) or picaridin) to their skin or clothing. Few studies have been conducted specifically on the prevention of *Bothriocroton* infestations, but sensible measures should include regular health surveillance, quarantine, strategic prophylactic treatments, environmental management (clearing excess vegetation, livestock pasture rotation, treating local environments with residual acaricides) and wildlife control (through fencing, trapping or hunting). In the case of captive wildlife collections, every effort should be made to keep vivaria clean and to not introduce infested animals into enclosures. Researchers have occasionally suggested the possibility for biological control as they have observed that off-host stages are particularly prone to predation, notably by ants.

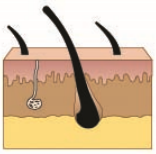
Bothriocroton



Hosts
(reptiles,
marsupials,
monotremes)

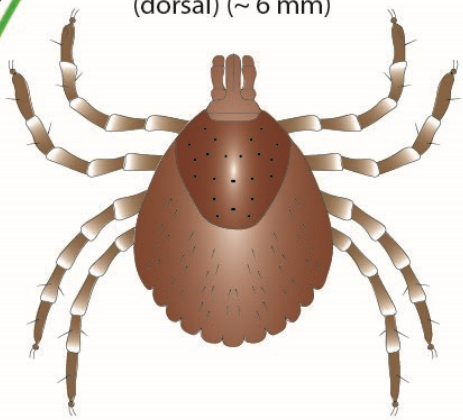
engorged female
(dorsal) (~ 15 mm)



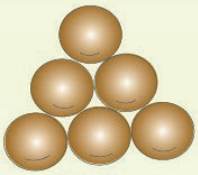


skin
(blood loss,
irritation,
lesions)
(vectors for
infectious
microbial
diseases)

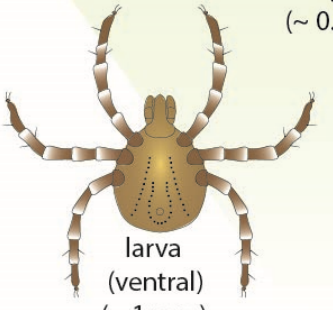
adult female
(dorsal) (~ 6 mm)



eggs laid in
moist soil

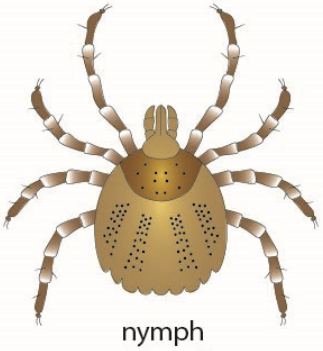


eggs
(~ 0.5 mm)



larva
(ventral)
(~ 1 mm)

hatch



nymph
(dorsal)
(~ 2 mm)

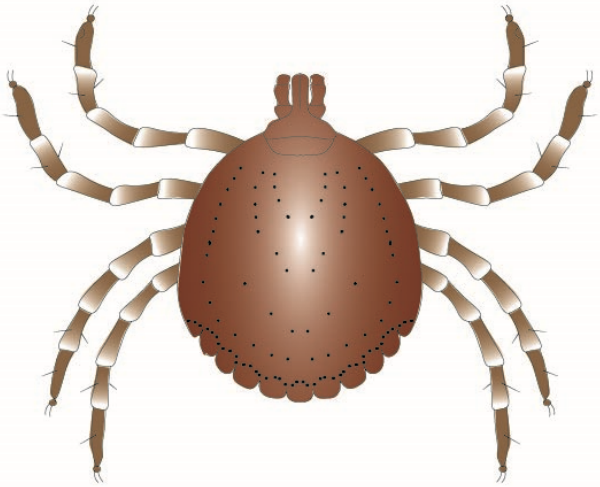
questing
(host-seeking)

motile stages (L, N, A)
are transient ectoparasites
on vertebrates (feed on blood)

Bothriocroton spp. (viz. Australian *Aponomma*)
have 3-host cycles where larvae (L), nymphs (N)
and adults (A) occur on different individual hosts

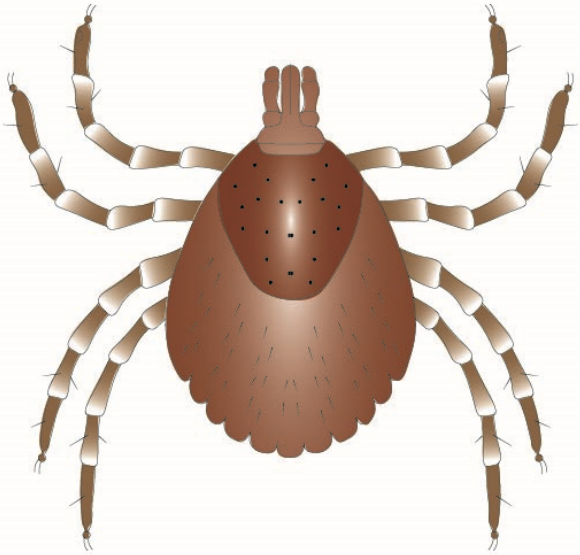
Bothriocroton

dorsal



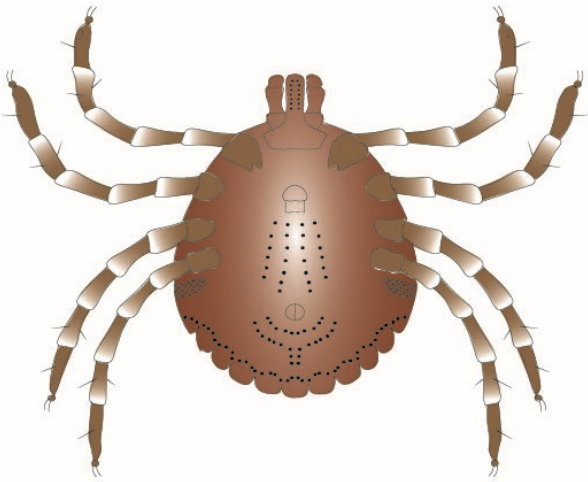
male (~ 4 mm)

dorsal

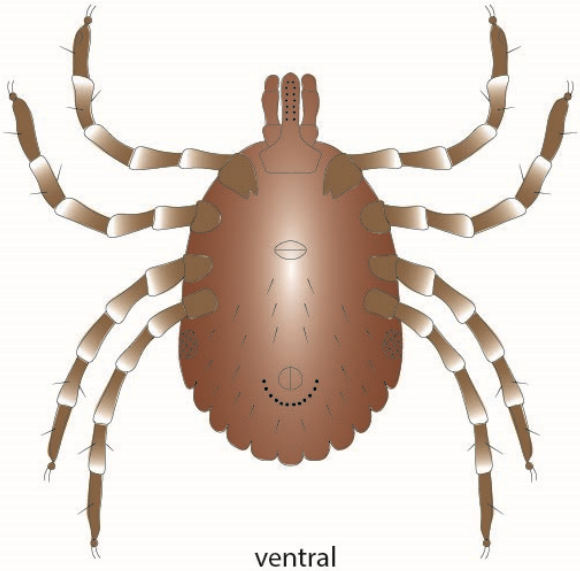


female (~ 6 mm)

adult ticks



ventral



ventral

Bothriocroton adult

Bothriocroton adult, engorged female