Dermacentor
(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 *Dermacentor* spp. are found as one- or three-host ticks on various mammals, sometimes causing paralysis and transmitting a range of microbial diseases.

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:	*Dermacentor* (parasitic on skin of mammals)
Species:	various species cause lesions and paralysis in mammals

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 Rhipicephalinae contains 7 genera (*Anomalohimalaya*, *Cosmiomma*, *Dermacentor*, *Margaropus*, *Nosomma*, *Rhipicentor* and *Rhipicephalus* (syn. *Boophilus p.p.*)) comprising metastriate ticks (often ornate) with eyes and festoons and adult males have ventral plates. The genus *Dermacentor* contains 34 species described from a range of mammals; with larval and nymphal stages found mainly on small ground-dwelling species while adult ticks prefer larger hosts such as carnivores and ungulates. They are medium-sized ticks with short mouthparts and an ornate scutum with posterior festoons and lateral eyes. Most species are thought to have 3-host life-cycles but some have 1-host cycles. Several species cause problems in animal health and production, with infestations causing local irritation, anaemia, reduced production and sometimes paralysis and mortality. Epidemiological and clinical studies have implicated several species in the transmission of various infectious disease (viral, bacterial and protozoal) to livestock.

***Dermacentor* species**	**Hosts**	**Clinical signs**	**Distribution**
D. abaensis (syn. *D. birulai, everestianus*, *Cynorhaestes*)	Artiodactyla: bovid (cattle, yak, dzo, sheep, bharal, Himalayan goral), camelid (camel), moschid (musk deer); Perissodactyla: equid (horse, onager); Lagomorpha: ochotonid (plateau pika, Chinese red pika, hare, rabbit); Rodentia: murid (wood mouse); Carnivora: ursid (Asian black bear) (3-host cycle)	(vector for anaplasmosis, rickettsioses)	China, Tibet
D. albipictus (syn. *D. salmoni, variegatus, varius, Cynorhaestes, C. nigrolineatus*) (winter tick, moose tick, elk tick, horse tick)	Artiodactyla: antilocaprid (pronghorn), bovid (cattle, American bison, sheep, bighorn sheep, mountain sheep, Barbary sheep, mountain goat), cervid (American moose, European fallow deer, mule deer, elk, wapiti, woodland caribou, white-tailed deer, Columbian black-tailed deer, red brocket); tayassuid (collared peccary); Perissodactyla: equid (horse, donkey, mule); Lagomorpha: leporid (rabbit, jackrabbit); Rodentia: castorid (beaver), caviid (guinea pig), cricetid (deer mouse, brush mouse), erethizontid (North American porcupine), heteromyid (Mexican spiny pocket mouse), murid (mouse); Carnivora: canid (wolf,	trauma, irritation, anaemia, paralysis (vector for anaplasmosis, borreliosis, rickettsial spotted fever)	North America

	coyote), felid (cat), ursid (American black bear); Primates: hominid (human); Accipitriformes: accipitrid (hawk); Charadriiformes: scolopacid (American woodcock) (1-host cycle)		
D. andersoni (syn. *D. venustus*) (Rocky Mountain wood tick)	Artiodactyla: antilocaprid (pronghorn), bovid (cattle, American bison, sheep, bighorn sheep, goat, mountain goat), cervid (mule deer, white-tailed deer, elk), suid (pig); Perissodactyla: equid (horse, donkey, mule); Lagomorpha: leporid (rabbit, pygmy rabbit, black-tailed jackrabbit, white-tailed jackrabbit, mountain cottontail, desert cottontail, snowshoe rabbit, hare, snowshoe hare), ochotonid (American pika); Eulipotyphla: soricid (American water shrew); Rodentia: caviid (guinea pig), cricetid (muskrat, bushy-tailed woodrat, desert woodrat, Mexican woodrat, deer mouse, pinyon mouse, northern grasshopper mouse, bank vole, meadow vole, southern red-backed vole, long-tailed vole, eastern meadow vole, montane vole, cantankerous vole, prairie vole, sagebrush vole, hamster), erethizontid (North American porcupine, yellow-haired porcupine), geomyid (pocket gopher), heteromyid (kangaroo rat, Ord's kangaroo rat, Great Basin pocket mouse), murid (house mouse, meadow mouse, western harvest mouse, white-footed mouse), sciurid (buff-bellied chipmunk, yellow pine chipmunk, cliff chipmunk, least chipmunk, pallid chipmunk, red-tailed chipmunk, painted chipmunk, yellow-bellied chipmunk, Uinta chipmunk, Colorado chipmunk, Siberian chipmunk, black-tailed prairie dog, groundhog, American red squirrel, Douglas squirrel, Abert's squirrel, rock squirrel, chickaree, golden-mantled ground squirrel, Montana mantled ground squirrel, thirteen-lined ground squirrel, little gray ground squirrel, California ground squirrel, Uinta ground squirrel, Belding's ground squirrel, Richardson's ground squirrel, Townsend's ground squirrel, Oregon ground squirrel, Columbian ground squirrel, Franklin's ground squirrel, northern flying squirrel, pallid yellow-bellied woodchuck, northern pocket gopher, yellow-bellied marmot, hoary marmot), zapodid (western jumping mouse); Carnivora: canid (dog, wolf, coyote), felid (cat, bobcat, lynx), mustelid (American badger, marten, long-tailed weasel, short-tailed weasel, stoat), mephitid (skunk), ursid (brown bear, grizzly bear, American black bear); Chiroptera: vespertilionid (Yuma myotis); Primates: hominid (human); Accipitriformes: accipitrid (unspecified); Galliformes: phasianid (ruffed grouse, turkey): Passeriformes: passerellid (vesper sparrow) (3-host cycle)	trauma, irritation, anaemia, paralysis (vector for babesiosis, theileriosis, anaplasmosis, rickettsial spotted fever, tularaemia, Colorado tick fever)	North America
D. antrorum	Rodentia: cricetid (common vole, European snow vole)		Central Asia
D. asper	Eulipotyphla: erinaceid (hedgehog)		China
D. atrosignatus	Artiodactyla: bovid (buffalo, water buffalo), suid (pig, banded pig, Bornean bearded pig, Palawan bearded pig, Celebes warty pig); Eulipotyphla: soricid (house shrew); Pholidota: manid (Sunda pangolin); Rodentia: murid (black rat, yellow-haired hill rat, Hellwald's Sulawesi maxomys, Hoffmann's Sulawesi rat, giant Sulawesi rat, Pacific rat, marmoset xanthurus rat); Carnivora: canid (dog), ursid (Malayan sun bear); Chiroptera: pteropodid (lesser tube-nosed fruit bat, Sulawesi rousette); Primates: hominid (human); Sauria: varanid (Asian water monitor); Serpentes: elapid (Indian cobra)		Malaysia
D. auratus (syn. *Indocentor, D. astrosignatus*)	Artiodactyla: cervid (chital, sambar deer, Indian sambar deer), suid (pig, banded pig, Indian boar, bushpig), tragulid (chevrotain); Perissodactyla: rhinocerotid (Sumatran rhinoceros); Eulipotyphla: erinaceid (moonrat); Scandentia: tupaiid (common treeshrew, pygmy treeshrew); Rodentia: caviid (guinea pig), hystricid (Indian crested porcupine), murid (house mouse, black rat, greater bandicoot rat, Annadale's rat, ricefield rat, Bower's white-toothed rat, southeast Asian house rat, long-tailed giant rat,		Indo-China

	Edward's long-tailed giant rat, Malayan field rat, Muller's giant Sunda rat, red spiny rat, Rajah spiny rat, Whitehead's spiny rat), sciurid (plaintain squirrel, variable squirrel, slender squirrel, Anderson's squirrel, Pallas's squirrel, Asian red-cheeked squirrel, three-striped ground squirrel, black giant squirrel, Indian giant squirrel); Carnivora: canid (dhole), felid (leopard cat, leopard, tiger), herpestid (small Asian mongoose), mustelid (hog badger, Burmese ferret-badger), ursid (sloth bear, Asian black bear), viverrid (small Indian civet, Asian palm civet); Primates: cercopithecid (bonnet macaque, northern plains brown langur); hominid (human); Galliformes: phasianid (chicken); Serpentes: pythonid (unspecified python)		
D. bellulus (syn. *Indocentor*)	Artiodactyla: bovid (water buffalo), suid (boar); Lagomorpha: leporid (Chinese hare); Scandentia: tupaiid (common treeshrew); Rodentia: murid (large Japanese field mouse, Ryukyu mouse, brown rat, black rat, oriental house rat, greater bandicoot rat, lesser bandicoot rat, Chinese white-bellied rat, Coxing's white-bellied rat, Losea rat,); Carnivora: canid (dog), mustelid (Chinese ferret-badger); Primates: hominid (human); Galliformes: phasianid (Chinese bamboo partridge)		Asia
D. circumguttatus (syn. *Amblyocentor*)	Artiodactyla: bovid (common duiker), suid (boar); Proboscidea: elephantid (African elephant, African forest elephant); Primates: hominid (human)		Africa
D. compactus (syn. *Indocentor*)	Artiodactyla: suid (banded pig, bushpig); Rodentia: murid (ricefield rat, Malaysian field rat, Muller's saundamys, Indomalayan leopoldamys), sciurid (gray-bellied squirrel, black-striped squirrel, plaintain squirrel, Prevost's squirrel, pale giant squirrel, black giant squirrel, shrew-faced squirrel, horse-tailed squirrel, Low's squirrel, slender squirrel, Javanese flying squirrel, Vordermann's flying squirrel, Himalayan striped squirrel); Carnivora: canid (dog), ursid (unspecified bear); Serpentes; colubrid (spotted keelback)		Indonesia
D. confragus (syn. *Indocentor*)	host unknown, collected from vegetation		Indonesia
D. cruentus	Artiodactyla: bovid (cattle, sheep, goat)		Europe
D. dispar	Artiodactyla: cervid (unspecified deer), tayassuid (white-lipped peccary); Cingulata: dasypodid (nine-banded armadillo)		Central America
D. dissimilis	Artiodactyla: bovid (cattle); Perissodactyla: equid (horse); Carnivora: canid (dog) (1-host cycle)		Americas
D. falsosteini	Artiodactyla: suid (pig, Bornean bearded pig); Perissodactyla: tapirid (tapir); Primates: hominid (human)		Asia
D. feae (syn. *D. foai*)	Testudines: geoemydid (Indian black turtle), testudinid (elongated tortoise)		
D. filippovae	Artiodactyla: suid (pig)		Asia
D. halli	Artiodactyla: bovid (cattle), tayassuid (collared peccary); Perissodactyla: equid (horse), tapirid (Baird's tapir); Rodentia: erethizontid (Mexican hairy dwarf porcupine), murid (mouse); Pilosa: bradypodid (sloth); Carnivora: canid (dog), mephitid (skunk); Chiroptera: vespertilionid (black myotis); Primates: hominid (human)		Americas
D. hunteri	Artiodactyla: bovid (bighorn sheep, desert bighorn sheep), cervid (mule deer); Lagomorpha: leporid (mountain cottontail); Rodentia: caviid (guinea pig), cricetid (desert woodrat, cactus mouse, deer mouse); Primates: hominid (human)		North America
D. imitans	Artiodactyla: cervid (red brocket, Central American red brocket), tayassuid (collared peccary, white-lipped peccary); Primates: hominid (human)		Central America
D. kamtshadalus (syn. *D. varius kamschadalus*)	Artiodactyla: bovid (sheep)		Asia
D. laothaiensis	Artiodactyla: suid (pig)		Asia
D. latus	Perissodactyla: tapirid (Baird's tapir); Carnivora: canid (dog);		Central

	Primates: hominid (human)		America
D. limbooliati	Artiodactyla: suid (pig); Primates: hominid (human)		Asia
D. marginatus (incl. subspp. *lacteolus*, *marginatus*) (syn. *Cynorhaestes*) (sheep tick)	Artiodactyla: bovid (cattle, water buffalo, sheep, goat, Siberian ibex, argali, mouflon), camelid (camel), cervid (red deer, fallow deer, roe deer, Siberian roe deer), suid (pig, boar); Perissodactyla: equid (horse, donkey); Eulipotyphla: erinaceid (long-eared hedgehog, northern white-breasted hedgehog, European hedgehog), soricid (common shrew, bicolored shrew, lesser white-toothed shrew, Eurasian water shrew), talpid (European mole); Lagomorpha: leporid (European rabbit, desert hare, mountain hare, tolai hare, European hare, Cape hare), ochotonid (steppe pika, Turkestan red pika, Pallas's pika); Rodentia: caviid (guinea pig), cricetid (common vole, bank vole, juniper vole, tundra vole, social vole, silver mountain vole, flat-headed vole, grey red-backed vole, northern red-backed vole, northern mole vole, European water vole, European snow vole, European pine vole, Tien Shan forest vole, narrow-headed vole, Carruther's vole, winter white dwarf hamster, golden hamster, European hamster, Turkish hamster, Chinese striped hamster, Eversmann's hamster, grey dwarf hamster, steppe lemming), dipodid (northern three-toed jerboa, dwarf fat-tailed jerboa, small five-toed jerboa, great jerboa, thick-tailed pygmy jerboa, thick-tailed three-toed jerboa, William's jerboa, Zhitkov's jerboa), glirid (garden dormouse, forest dormouse, hazel dormouse, European edible dormouse), murid (house mouse, striped field mouse, Ural field mouse, yellow-necked mouse, wood mouse, eastern broad-toothed field mouse, Eurasian harvest mouse, Black Sea mouse, brown rat, Turkestan rat, Libyan jird, Tamarisk jird), sciurid (red squirrel, red-cheeked ground squirrel, yellow ground squirrel, russet ground squirrel, little ground squirrel, relict ground squirrel, spectacled ground squirrel, European ground squirrel, Brandt's ground squirrel, grey marmot, long-tailed marmot), sminthid (southern birch mouse, Nordmann's birch mouse), spalacid (greater blind mole-rat); Carnivora: canid (dog, wolf, red fox), felid (cat, wildcat), mustelid (stoat, steppe polecat, European polecat, least weasel, European badger, European pine marten), procyonid (raccoon), ursid (brown bear); Chiroptera (unspecified bat); Primates: hominid (human); Accipitriformes: accipitrid (cinereous vulture, black kite); Bucerotiformes: upupid (Eurasian hoopoe); Charadriiformes: burhinid (Eurasian stone curlew); Columbiformes: columbid (rock dove, European turtle dove); Coraciiformes: coraciid (European roller), meropid (European bee-eater); Galliformes: phasianid (common quail); Passeriformes: alaudid (crested lark, horned lark, Mediterranean short-toed lark), corvid (carrion crow, western jackdaw), emberizid (corn bunting), hirundinid (swallow), laniid (brown shrike), motacillid (citrine wagtail), muscicapid (bluethroat, common rockthrush), passerid (sparrow); sturnid (common starling), turdid (thrush); Strigiformes: strigid (owl); Sauria: lacertid (sand lizard, European green lizard); Anura: ranid (unspecified frog) (3-host cycle)	trauma, irritation (vector for babesiosis, theileriosis, anaplasmosis, Q fever, Rocky Mountain spotted fever, tularaemia, brucellosis, rickettsial Boutonneuse fever, Omsk haemorrhagic fever, Russian spring-summer viral encephalitis)	Europe
D. modestus	Perissodactyla: equid (horse)		North America
D. montanus	Artiodactyla: bovid (cattle); Lagomorpha: ochotonid (Turkestan red pika); Rodentia: cricetid (vole), murid (unspecified), sciurid (long-tailed marmot)		Central Asia
D. nitens (syn. *Anocentor colombianus*) (tropical horse tick)	Artiodactyla: bovid (cattle, buffalo, sheep, goat), cervid (marsh deer, white-tailed deer, brown brocket), suid (pig); Perissodactyla: equid (horse, mule, donkey), tapirid (South American tapir, Baird's tapir); Rodentia: caviid (capybara), cuniculid (lowland paca); Carnivora: canid (dog, hoary fox, crab-eating fox), felid (cat, oncilla, ocelot, jaguar, cougar, Florida	trauma, irritation (vector for babesiosis and possibly rickettsiosis)	Americas

	panther), herpestid (small Asian mongoose); Primates: hominid (human); Serpentes: boa (Cuban tree boa); Anura: bufonid (eastern giant toad) (1-host cycle)		
D. niveus (syn. *Cynorhaestes, D. daghestanicus*) (possible synonym of *D. marginatus*)	Artiodactyla: bovid (cattle, zebu, sheep, goat, wild goat), camelid (camel), cervid (red deer, maral deer, roe deer, Siberian roe deer, sika deer, Bactrian deer, reindeer), suid (pig, boar); Perissodactyla: equid (horse, donkey); Eulipotyphla: erinaceid (long-eared hedgehog, European hedgehog, Brandt's hedgehog); Lagomorpha: leporid (desert hare, tolai hare, European hare), ochotonid (steppe pika, Afghan pika); Rodentia: cricetid (common vole, narrow-headed vole, European water vole, European snow vole, grey dwarf hamster, European hamster, Eversmann's hamster, steppe lemming), dipodid (dwarf fat-tailed jerboa, small five-toed jerboa, great jerboa), glirid (forest dormouse), murid (house mouse, striped field mouse, wood mouse, short-tailed bandicoot rat, Turkestan rat, Libyan jird, Tamarisk jird, Persian jird, great gerbil), sciurid (yellow suslik, little ground squirrel, Brandt's ground squirrel, bobak marmot); Carnivora: canid (dog, wolf, golden jackal, red fox), felid (cat); Chiroptera (unspecified bat); Primates: hominid (human); Accipitriformes: accipitrid (tawny eagle); Coraciiformes: coraciid (European roller); Passeriformes: corvid (carrion crow), emberizid (red-headed bunting), laniid (great grey shrike), muscicapid (common nightingale, thrush nightingale), passerid (house sparrow); Testudines: testudinid (Greek tortoise)		Africa, Eurasia
D. nuttalli	Artiodactyla: bovid (cattle, sheep, goat), camelid (camel), suid (pig); Perissodactyla: equid (horse, onager); Eulipotyphla: erinaceid (hedgehog); Lagomorpha: leporid (tolai hare), ochotonid (Daurian pika, Pallas's pika); Rodentia: cricetid (common vole, reed vole, narrow-headed vole, tundra vole, silver mountain vole, grey-red-backed vole, northern red-backed vole, Blyth's vole, long-tailed dwarf hamster, European hamster, Chinese striped hamster, Mongolian hamster, Roborovski's dwarf hamster, winter white dwarf hamster), dipodid (northern three-toed jerboa, Mongolian five-toed jerboa, Siberian jerboa), murid (striped field mouse, yellow-necked mouse, Eurasian harvest mouse, midday jird, Mongolian gerbil), sciurid (long-tailed ground squirrel, Daurian ground squirrel, Tarbagan marmot); Carnivora: canid (dog, wolf, corsac fox), felid (cat), mustelid (ferret, weasel, European badger); Primates: hominid (human); birds (3-host cycle)	trauma, irritation (vector for rickettsiosis)	Russia, China
D. occidentalis (Pacific coast tick)	Artiodactyla: bovid (cattle, sheep, goat, mountain goat), cervid (mule deer, black-tailed deer, elk); Perissodactyla: equid (horse, donkey, mule); Lagomorpha: leporid (desert cottontail, brush rabbit, rock rabbit, black-tailed jackrabbit, hare); Rodentia: caviid (guinea pig), cricetid (brush mouse, deer mouse, California deer mouse, pinyon mouse, white-footed mouse, large-eared woodrat, bushy-tailed woodrat, dusky-footed woodrat, desert woodrat, California vole), dipodid (kangaroo rat), heteromyid (pocket mouse), heteromyid (California pocket mouse), murid (house mouse, white-footed mouse, western harvest mouse, mountain rat), sciurid (rock squirrel, pine squirrel, Douglas squirrel, western grey squirrel, golden-mantled ground squirrel, California ground squirrel, Douglas ground squirrel, Merriam chipmunk, Townsend's chipmunk, Siskiyou chipmunk, gopher, woodchuck); Carnivora: canid (dog, coyote, gray fox), mephitid (striped skunk, western spotted skunk), procyonid (raccoon); Primates: hominid (human) (3-host cycle)	trauma, irritation, paralysis (vector for anaplasmosis, Q fever, Colorado tick fever, tularaemia)	North America
D. panamensis	Rodentia: cricetid (Aztec mouse, Mexican deer mouse, Chiriqui harvest mouse, Mexican harvest mouse, Alston's brown mouse,		Central America

	Peter's climbing rat, yellow pygmy rice rat, large-headed rice rat, yellow isthmus rat, Sumichrast's vesper rat, Boquete rice rat), erethizontid (Mexican hairy dwarf porcupine), heteromyid (Desmarest's spiny pocket mouse, Panamanian spiny pocket mouse), sciurid (red-tailed squirrel); Pilosa: bradypodid (sloth); Chiroptera: vespertilionid (black myotis, Chilean myotis)		
D. parumapertus (syn. *Cynorhaestes*)	Artiodactyla: bovid (cattle), cervid (Columbian black-tailed deer); Lagomorpha: leporid (desert cottontail, mountain cottontail, antelope jackrabbit, black-tailed jackrabbit, white-tailed jackrabbit, California jackrabbit, Colorado desert jackrabbit, Great Plains jackrabbit, pygmy rabbit, hare); Rodentia: cricetid (northern grasshopper mouse, southern grasshopper mouse, deer mouse, canyon mouse, pinyon mouse, cactus mouse, bushy-tailed woodrat, desert woodrat, southern plains woodrat, packrat), dipodid (desert kangaroo rat, Merriam's kangaroo rat, Mohave kangaroo rat, chisel-toothed kangaroo rat, Ord's kangaroo rat, Richardson's kangaroo rat, banner-tailed kangaroo rat), geomyid (Botta's pocket gopher), heteromyid (little pocket mouse, long-tailed pocket mouse, Great Basin pocket mouse, Tejon pocket mouse, dark kangaroo mouse), murid (brown rat, western harvest mouse), sciurid (spotted ground squirrel, thirteen-lined ground squirrel, rock squirrel, white-tailed antelope squirrel, cliff chipmunk, least chipmunk, white-tailed prairie dog, black-tailed prairie dog, marmot); Carnivora: canid (coyote, kit fox), felid (cat, bobcat), procyonid (ringtail); Primates: hominid (human); Accipitriformes: accipitrid (golden eagle); Galliformes: phasianid (chicken)		Nearctic
D. pasteuri (syn. *Indocentor*)	Artiodactyla: suid (boar)		Asia
D. pavlovskyi	Artiodactyla: bovid (cattle, sheep, argali, goat, Siberian ibex), camelid (camel); Perissodactyla: equid (horse); Lagomorpha: leporid (tolai hare), ochotonid (large-eared pika); Rodentia: cricetid (silver mountain vole, juniper vole, narrow-headed vole, Carruther's vole, northern mole vole, grey dwarf hamster), murid (wood mouse), sciurid (gray marmot, long-tailed marmot), sminthid (birch mouse); Carnivora: canid (red fox); Passeriformes: corvid (red-billed chough)	(vector for brucellosis)	Central Asia
D. pomerantzevi	Eulipotyphla: erinaceid (European hedgehog)		Russia
D. pseudocompactus	Artiodactyla: suid (pig)		Nepal
D. raskemensis	Artiodactyla: bovid (yak, zo, sheep, goat); Lagomorpha: leporid (hare), ochotonid (pika); Rodentia: calomyscid (mouse-like hamster); Carnivora: canid (dog); Primates: hominid (human)		Eurasia
D. reticulatus (syn. *D. albicollis, ferrugineus, pictus, pardalinus, punctulatus, Ixodes holsatus*, *Haemaphysalis marmorata*) (marsh tick, meadow tick, ornate cow tick)	Artiodactyla: bovid (cattle, water buffalo, sheep, argali, goat), camelid (dromedary), cervid (moose, red deer, wapiti, roe deer, Siberian roe deer, European fallow deer), hippopotamid (hippopotamus), suid (pig, Sardinian wild boar); Perissodactyla: equid (horse, donkey), rhinocerotid (black rhinoceros); Eulipotyphla: erinaceid (northern white-breasted hedgehog, European hedgehog), soricid (common shrew, Eurasian pygmy shrew, Eurasian water shrew), talpid (European mole); Lagomorpha: leporid (European hare, mountain hare, European rabbit), ochotonid (steppe pika); Rodentia: cricetid (muskrat, common vole, bank vole, tundra vole, social vole, narrow-headed vole, short-tailed field vole, grey red-backed vole, northern red-backed vole, European pine vole, European water vole, European snow vole, European hamster), dipodid (great jerboa), glirid (forest dormouse), murid (house mouse, striped field mouse, yellow-necked mouse, wood mouse, Eurasian harvest mouse, brown rat), sciurid (red squirrel, red-cheeked ground squirrel, Siberian chipmunk, bobak marmot), sminthid (northern birch mouse); Carnivora: canid (dog, wolf, red fox), felid (cat), mustelid (European badger, stoat, least weasel, steppe polecat, European polecat, ferret, European pine marten); Chiroptera:	trauma, irritation (vector for babesiosis, theileriosis, Q fever, tularaemia, brucellosis, rickettsial Boutonneuse fever, anaplasmosis, Omsk haemorrhagic fever, infectious encephalomyelitis)	Europe, Africa

	miniopterid (common bentwing bat), rhinolophid (Geoffroy's horseshoe bat), vespertilionid (brown long-eared bat); Primates: hominid (human); Charadriiformes: charadriid (plover), scolopacid (green sandpiper); Columbiformes: columbid (European turtle dove); Gruiformes: otid (bustard); Passeriformes: corvid (Eurasian jay), motacillid (meadow pipit), parid (great tit), sittid (Eurasian nuthatch), turdid (true thrush, fieldfare); Sauria: lacertid (sand lizard, ocellated lizard, European green lizard); Serpentes: boid (boa); Anura: ranid (unspecified frog) (3-host cycle)		
D. rhinocerotis (syn. *Amblyocentor, Amblyomma petersi, rhinocerinus, Ixodes*)	Artiodactyla: bovid (cattle, buffalo, forest buffalo, sheep, common eland, blackbuck, roan antelope), hippopotamid (hippopotamus), suid (warthog); Perissodactyla: equid (donkey), rhinocerotid (black rhinoceros, white rhinoceros, northern white rhinoceros); Proboscidea: elephantid (elephant); Rodentia: murid (mouse); Carnivora: canid (jackal), felid (lion); Primates: hominid (human); Sauria: varanid (monitor); Serpentes: pythonid (unspecified python); Testudines (unspecified tortoise)		Africa
D. rosmari *nomen nudum*	Carnivora: odobenid (walrus)		Russia
D. silvarum (incl. subspp. *ablutus, silvarum*) (syn. *D. asiaticus*)	Artiodactyla: bovid (cattle, sheep, goat), camelid (camel), cervid (red deer, Chinese roe deer, Siberian roe deer, sika deer, elk, reindeer), suid (pig); Perissodactyla: equid (horse, donkey); Eulipotyphla: erinaceid (long-eared hedgehog, northern white-breasted hedgehog, European hedgehog), soricid (common shrew, Eurasian pygmy shrew, Eurasian water shrew); Lagomorpha: leporid (mountain hare, European hare, Manchurian hare), ochotonid (alpine pika); Rodentia: cricetid (common vole, reed vole, narrow-headed vole, tundra vole, Bucharian vole, transcaspian vole, Maximoxicz's vole, European water vole, grey red-backed vole, northern red-backed vole, giant rat-headed hamster, Chinese hamster, European hamster, steppe lemming), dipodid (great jerboa, dwarf fat-tailed jerboa), murid (house mouse, striped field mouse, Large Japanese field mouse, wood mouse, Eurasian harvest mouse, black rat, brown rat), sciurid (red squirrel, long-tailed ground squirrel, little ground squirrel, russet ground squirrel, speckled ground squirrel, Asian chipmunk, Siberian chipmunk), sminthid (northern birch mouse, southern birch mouse), spalacid (greater blind mole-rat); Carnivora: canid (dog, raccoon dog, wolf, red fox), felid (cat, leopard cat, Siberian tiger), mustelid (yellow-throated marten, sable, steppe polecat, least weasel, Siberian weasel); Primates: hominid (human); Charadriiformes: scolopacid (Swinhoe's snipe); Columbiformes: columbid (Oriental turtle dove); Galliformes: phasianid (hazel grouse); Passeriformes: acrocephalid (thick-billed warbler), emberizid (yellow-breasted bunting, meadow bunting, black-faced bunting, chesnut bunting, chesnut-eared bunting), motacillid (olive-backed pipit), passerid (sparrow), phylloscopid (dusky warbler), sittid (Eurasian nuthatch), sylviid (babbler); Piciformes: picid (lesser spotted woodpecker, hairy woodpecker); Sauria: lacertid (European green lizard) (3-host cycle)	trauma, irritation, paralysis (vector for piroplasmosis, anaplasmosis, rickettsial typhus)	Asia
D. similis	host unknown, collected from vegetation		North America
D. sinicus (incl. subspp. *pallidor, sinicus)*	Eulipotyphla: erinaceid (hedgehog); Rodentia: caviid (guinea pig), cricetid (hamster)		Eurasia
D. steini (syn. *Indocentor ater, steini*)	Artiodactyla: bovid (water buffalo, goat), suid (pig, wild boar, banded pig, Bornean bearded pig, Palawan bearded pig, Celebes warty pig, Philippine warty pig), tragulid (Java mouse-deer); Perissodactyla: tapirid (Malayan tapir); Pholidota: manid (Sunda		Asia

	pangolin); Rodentia: hystricid (Asiatic brush-tailed porcupine), murid (long-tailed giant rat, Muller's giant Sunda rat); Carnivora: canid (dog), felid (leopard, tiger), ursid (Malayan sun bear), viverrid (small-toothed palm civet); Primates: hominid (human); Sauria: varanid (Asian water monitor); Serpentes: elapid (king cobra), pythonid (reticulated python)		
D. taiwanensis	Artiodactyla: suid (boar); Lagomorpha: leporid (Chinese hare); Rodentia: murid (greater bandicoot rat), sciurid (Pallas's squirrel, Himalayan striped squirrel); Carnivora: canid (dog), mustelid (Chinese ferret-badger, Siberian weasel), ursid (giant panda, Asian black bear); Galliformes: phasianid (Chinese bamboo partridge)		Asia
D. tamokensis	Artiodactyla: suid (pig)		Indo-China
D. (*Serdjukovia*) *ushakovae* (possible synonym of *D. marginatus*)	Artiodactyla: bovid (cattle); Lagomorpha: leporid (hare); Rodentia: cricetid (vole), dipodid (jerboa), murid (mouse)		Central Asia
D. variabilis (syn. *D. americanus, electus, Ixodes quinquestriatus*) (American dog tick, wood tick)	Artiodactyla: bovid (cattle, sheep, goat), cervid (moose, white-tailed deer, sambar deer), suid (pig), tayassuid (collared peccary); Perissodactyla: equid (horse, donkey, mule); Lagomorpha: leporid (rabbit, eastern cottontail, desert cottontail, black-tailed jackrabbit, white-sided jackrabbit, marsh rabbit, swamp rabbit, snowshoe hare); Didelphimorphia: didelphid (common opossum, Virginia opossum); Eulipotyphla: soricid (common shrew, Say's least shrew, northern short-tailed shrew, long-tailed shrew), talpid (eastern mole); Rodentia: caviid (guinea pig), cricetid (meadow vole, prairie vole, eastern meadow vole, pine vole, woodland vole, western harvest mouse, eastern harvest mouse, deer mouse, golden mouse, cotton mouse, white-footed mouse, Oldfield mouse, hispid cotton rat, marsh rice rat, muskrat, eastern woodrat, southern plains woodrat, packrat), erethizontid (North American porcupine), geomyid (pocket gopher), heteromyid (Baird's pocket mouse), murid (house mouse, field mouse, golden harvest mouse, Cooper's mouse, black rat, brown rat, gray rat), sciurid (groundhog, woodchuck, red squirrel, fox squirrel, eastern gray squirrel, thirteen-lined ground squirrel, Franklin's ground squirrel, Richardson's ground squirrel, southern flying squirrel, eastern chipmunk), zapodid (meadow jumping mouse); Carnivora: canid (dog, red wolf, coyote, red fox, kit fox, gray fox), felid (cat, wildcat, Florida bobcat, Florida panther, mountain lion, jaguar, Mexican cougar), mephetid (striped skunk, spotted skunk), mustelid (wolverine, North American river otter, American badger, stoat, weasel, fisher, ferret), phocid (unspecified seal), procyonid (raccoon), ursid (American black bear), viverrid (civet); Chiroptera (unspecified pygmy bat); Primates: hominid (human); Apodiformes: apodid (chimney swift); Galliformes: odontophorid (northern bobwhite); Passeriformes: cardinalid (cardinal), corvid (crow), emberizid (painted bunting), icterid (red-winged blackbird, cowbird), mimid (mockingbird), parulid (palm warbler), passerellid (white-crowned sparrow, junco, eastern towhee), sturnid (starling), troglodytid (Carolina wren), turdid (American robin); Sauria: agamid (unspecified) (3-host cycle)	trauma, irritation, paralysis (vector for anaplasmosis, ehrlichiosis, rickettsial spotted fever, tularaemia, cytauxzoonosis, Lyme disease, encephalitis virus)	North America

Parasite morphology: *Dermacentor* spp. form 4 different morphological types of developmental stages: eggs, larvae, nymphs and adults. Eggs are small brown ovoid stages measuring 0.4-0.5 mm in diameter and they are often clustered together in small masses. Larvae are roughly discoidal (dorsoventrally flattened, oval-pyriform in dorsal profile) measuring up to 0.6 mm in length. They are usually yellow-brown in colour but may become slaty grey-black when engorged. The head (capitulum) projects forward anteriorly and contains conspicuous palps and mouthparts. The body (idiosoma) has a hardened anterodorsal plate (scutum) that occasionally has irregular patches of white enamel ornamentation. The scutum has posterior festoons, 2 lateral flat eyes (sometimes with adjacent red markings) and 3 pairs of long jointed legs arising ventrally. Larvae lack respiratory openings (stigmata) and the ventral

subterminal anus is not encompassed by an anal groove. Nymphs also have discoidal ovate bodies but they are larger ranging from 1-4 mm in length. They have similar features and colouration to larvae, but have 4 pairs of long ventral legs, one pair of respiratory stigmata surrounded by round plates, and the anus has a posterior anal groove, but they lack genital openings (gonopores). Adult ticks have pyriform bodies that are ventrally flattened but dorsally convex. They range in length from 3-5 mm when unfed, while engorging females may distend up to 10-16 mm long. They are typically ornate ticks with reddish-brown bodies adorned with gray-silver markings. 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 supporting mouthparts) and gnathosoma (bearing mouthparts). The basis capitulum is rectangular (not triangular, hexagonal or pentagonal) and the dorsal surface has 2 porose areas (clusters of pores used for waterproofing eggs during oviposition). The piercing/sucking mouthparts are short (same length as basis capitulum but as wide or wider) and comprise 2 sensory lateral palps and a central hypostome flanked by 2 chelicerae. The palps are short and broad (often wider than long) and do not enter the skin when feeding. The chelicerae have tubular shafts tipped with digits with recurved teeth used to cut and tear skin forming pools of blood. The barbed hypostome is inserted into the blood pools to facilitate feeding as well as to anchor the tick to the host. A feeding tube is formed between the chelicerae and hypostome to suck blood and inject saliva from long paired salivary glands. The alimentary tract consists of a muscular pharynx, a short tubular oesophagus, a large saccular midgut (ventriculus) with lateral diverticula (caeca), a short intestine (with excretory Malpighian tubules), a rectal sac and a subterminal ventral anus with a posterior (metastriate) anal groove. The idiosoma bears a conspicuous shield-like scutum which occupies most of the dorsum in males (= conscutum) but is restricted to an anterodorsal shield in females. The scutum is ornate (with pale enamel markings) and has 2 simple eyes located on the anterior margins. The idiosoma has a series of indentations (festoons) along the posterior margin, which are indistinct in engorged females. The ventral idiosoma bears 4 pairs of long jointed legs which often appear paler than the body or sometimes have light-coloured ends to some segments (but not evident as distinct rings). Each leg consists of 6 segments (coxae, trochanter, femur, patella (genu), tibia, and tarsus) and terminates in a pair of claws with a pad-like pulvillus. The coxae increase in size posteriad with coxae IV greatly enlarged in males, coxae 1 bearing 2 large spurs (in both sexes), and tarsi I having a unique sensory structure (Haller's organ) used to detect host odours, heat and vibrations. Respiratory stigmata are located behind coxae IV and the spiracular plates are paler and containing numerous shallow depressions (termed goblets). Adult ticks display marked sexual dimorphism, particularly in body size (males 3-5 mm, females 4-16 mm), colouration (females usually more colourful), scutum size (large covering plate in males, small anterior shield in females), and the occurrence of porose areas on the basis capitulum (present only on females). Adult male ticks do not have sclerotized ventral plates, which are present in the genera *Ixodes*, *Amblyomma*, *Rhipicephalus*/*Boophilus*, and *Hyalomma*. They have paired tubular testes, vas efferentia fusing to form a common vas deferens (with a multilobular accessory gland) and an ejaculatory duct leading to the genital aperture (gonopore) situated on the ventral midbody. Adult females have a saccular ovary with paired oviducts leading to a common uterus (with accessory glands) and a bipartite vagina (cervical region acting as a receptaculum seminis to store spermatophores, and vestibular region prolapsing during oviposition). The anteroventral gonopore is U-shaped with an anterior flap (genital apron) and located near a special glandular structure (Gene's organ) used to produce waxy coatings for eggs during oviposition.

Site of infection: The larvae, nymphs and adults of *Dermacentor* spp. are ectoparasitic on the skin of a wide range of vertebrate hosts: including mammals belonging to 55 families in 14 orders (ungulates, insectivores, marsupials, shrews, lagomorphs, rodents, carnivores, bats and primates), birds belonging to 20 passerine families and 14 non-passerine families in 10 orders (shore birds, landfowl, kingfishers, doves, birds of prey), reptiles belonging to 4 snake families, 3 lizard families and 2 tortoise families, and amphibians belonging to 2 frog families. Most species have diverse host ranges, as the larval and nymphal stages tend to occur on smaller ground-dwelling animals than adult stages. Feeding stages exhibit some site preferences, generally infesting the head, neck, groin and back, although they may occur in other regions in heavy infestations. Those species infesting humans usually migrate to the head behind the ears, or attach underneath waistbands or hems of tight-fitting clothing.

Pathogenesis: All motile stages are transient haematophagous parasites that feed once on host blood for several days before dropping off to develop further in the external environment. They use their cutting chelicerae to lacerate the skin creating pools of blood in the dermis from which they imbibe blood (feeding process known as telmophagy). They embed their mouthparts in feeding lesions using proteinaceous salivary cement and inject other salivary compounds with cytolytic, analgesic, anticoagulant, vasodilatory and vascular permeability activities. Their bites not only result in local tissue trauma but cause considerable dermal irritation with inflammation (erythema, oedema), pruritus, granuloma formation, rough coat and even alopecia. Heavy infestations may cause significant blood loss resulting in anaemia, iron deficiencies and even exsanguination in extremes cases. Infestations of the ears cause otoacariasis with inflammation and waxy discharges. Ticks may cause severe biting stress (tick worry) to their hosts, which may elicit aggressive grooming behaviours (licking, biting, scratching, rubbing) resulting in self-trauma and opening wounds to secondary bacterial infections. Livestock may be distracted from feeding efficiently and show loss of condition, poor growth and reduced meat and/or milk production. Some individual animals may also develop hypersensitivity reactions to tick saliva resulting in enhanced inflammation and granuloma formation. The saliva of several tick species (notably *D. variabilis* and *D. andersoni*) may also cause flaccid ascending paralysis in canines, ungulates and sometimes humans (particularly children) due to the presence of neurotoxins affecting motor function, reflexes, coordination and respiration, sometimes proving fatal. Feeding ticks may also act as biological and mechanical vectors for the transmission of various microbial infectious diseases. They are efficient vectors because they move frequently between hosts (most have 3-host life-cycles), microbes may multiply in tick tissues (amplification vectors) and survive metamorphic changes (trans-stadial transmission), with some even undergoing vertical transfer by infecting tick eggs (trans-ovarian transmission). Ticks may transmit microbes either during feeding (via saliva), during fluid regulation (via regurgitation) or

during waste elimination (via defaecation). *Dermacentor* spp. have been shown to transmit haemoprotozoa causing babesiosis, rickettsial bacteria causing Rocky Mountain spotted fever and anaplasmosis, coccobacilli causing tularemia, Gram-negative bacteria causing chlamydiosis, and viruses causing Powassan encephalitis virus, tick-borne encephalitis, Colorado tick fever and Omsk haemorrhagic fever.

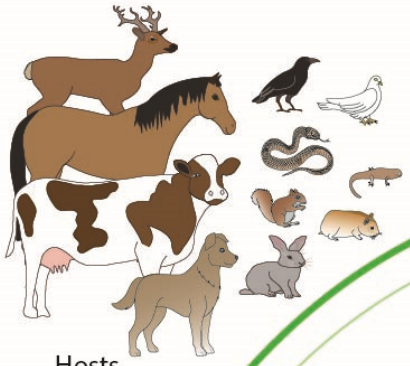
Developmental cycle and mode of transmission: Like all ticks, *Dermacentor* spp. undergo incomplete (hemimetabolous) metamorphosis where eggs hatch larvae which moult to nymphs and then adults. Most species have 3-host life-cycles where each stage feeds on a separate host, but some species (e.g. *D. albipictus, D. nitens*) have one-host cycles where all stages occur on the same host. Gravid females lay eggs in soil or humus where they hatch in 26-40 days (longer in colder conditions). The emergent 6-legged larvae climb vegetation and wait for passing hosts (ambush strategy). They actively quest (wave their forelegs in the air) when stimulated by sensory cues (odours, heat, vibrations) associated with the close proximity of a host. They may survive for several weeks to months (up to 11 months) depending on prevailing environmental conditions (they are prone to desiccation in warm dry conditions). Most species have preferred hosts (generally small ground-dwelling animals, especially rodents) and are reluctant to feed on unusual hosts (as evidenced by prolonged probing, taking small meal samples and then dropping off to seek and alternative host). Having located a suitable host, they attach and feed for several days (2-14 days depending on species) before detaching and dropping off when replete. On the ground, they shelter in the litter to digest their bloodmeals over a week (longer in colder conditions) before moulting to 8-legged nymphs (only one nymphal instar is formed, whereas argasids form 2-7 nymphal instars). Nymphs ascend vegetation and quest for hosts, surviving for several weeks to months depending on prevailing conditions. They attach to suitable hosts and feed for 3-10 days before dropping off to digest their meals over 3 weeks to several months. Nymphs then moult into adult ticks (both male and female) which climb vegetation (often along trails and tracks) and quest for hosts (most species seek larger animals). Adults have been shown to survive without feeding for up to 2 years, even in adverse environmental conditions. Once a suitable host is located, the adult ticks attach and begin feeding (both sexes requiring a bloodmeal to mature). Mating occurs on hosts when males detach and search the host for receptive attached females. Females mate once and then continue feeding for 6-14 days until they become massively engorged with host blood. Females then detach and seek shelter in ground litter for 4-10 days before laying large batches of eggs (totaling up to 4,000-6,500) over several days to weeks. The whole life-cycle may be completed in as little as 54 days, but it usually takes 1-3 years depending on host availability and climatic factors. Many species exhibit some seasonality, being most active on hosts over autumn and winter. Most species inhabit temperate and cold regions, being found mainly in open landscapes (steppes, forest-steppes, savannas, sparsely forested areas with wooded, shrubby and long-grass areas).

Differential diagnosis: Infestations may be suspected on clinical grounds (skin lesions, anaemia, illthrift, even paralysis) but all symptoms/signs are variable, nonspecific and hence not pathognomonic. Diagnoses are made by the direct detection of feeding stages on hosts, followed by their collection for microscopic examination and identification (medium-sized ornate ticks with festoons and eyes, rectangular basis capituli, medium palps, short mouthparts, male ventral plates absent). Ticks may be preserved by freezing of fixation for subsequent molecular studies, and free-living stages may also be collected from the environment by blanket drags or dry-ice traps. Various molecular biological techniques have been used to characterize species and infer 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.

Treatment and control: Individual ticks may be physically removed from humans and compliant animals using fine tweezers or special removal devices (tick keys, lassos, twists or V-shaped tools), but taking care not to crush and tear them as tick secretions and fragments may cause further inflammation and even systemic reactions. Symptomatic relief may be afforded by the application of topical disinfectants, analgesics, antipuritics, antihistamines or even antibiotics to prevent secondary infections. Although the literature is riddled with many suggestions to apply freezing agents, solvents or volatile fluids to the backs of ticks, such treatments should be used cautiously as they may also increase the risk of systemic reactions as stricken ticks may release potentially toxic compounds. More conventionally, infestations on livestock and companion animals are treated using chemical acaricides, including arsenical preparations, organochlorines (dichloro-diphenyl-trichloroethane (DDT), lindane), organophosphates (dioxathion, fenchlorphos), organophosphonates (chlorfenvinphos, dichlorvos, tetrachlorvinphos, trichlorfon), monothiophosphates (chlorpyrifos, coumaphos, cythioate, diazinon, fenthion, propetamphos), dithiophosphates (malathion, phosmet), carbamates (carbaryl), pyrethroids (permethrin, flumethrin, deltamethrin, decamethrin, cypermethrin, cyprothrin, alphametrin), formamidines (amitraz), macrocyclic lactones (ivermectin, selamectin), phenylpyrazoles (fipronil), chloronicotinyls (imidacloprid), isoxazolines (afoxolaner, fluralaner), some natural products (rotenone) and some insect growth regulators (methoprene, pyriproxyfen). These chemicals are available as a range of dips, footbaths, sprays, showers, dusts, emulsions, pour-ons, spot-ons, collars, eartags, tailtags, tablets, chewables, drenches, or injections. Repeated treatments are often required as animals may become rapidly re-infested, but the use of slow-release formulations or those with long-lasting residual activity helps reduce treatment frequency. Regrettably, the incorrect and over-usage of some acaricides has resulted in the development of drug resistance in many tick populations, particularly against arsenic compounds, organochlorines, and some organophosphates, pyrethroids and formamidines. It is therefore recommended that different classes of acaricides be used in cyclic rotation or as cocktail co-formulations, if possible after resident ticks have been tested for resistance using *in situ* or *in vitro* egg hatch, larval development, or adult survival tests. Because resistance

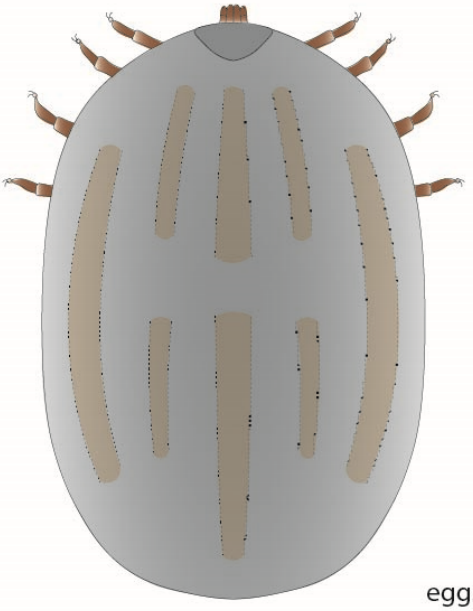
tests take a long time to perform, several studies are attempting to develop faster tests using immunoassays or molecular screening tests. A number of preventive strategies have also been recommended to break transmission cycles through integrated animal and environmental management. Livestock should undergo regular health surveillance that informs strategic treatment, stocking density (including cohort separation), quarantine (especially during translocations) and even culling (removing heavily-infested animals). Because ticks spend more time in the environment than on hosts, efforts should be directed at reducing pasture contamination and making the surrounding landscape inhospitable (pasture rotation, spelling or cultivation; clearing encroaching vegetation, especially along fence lines; applying residual acaricides; cleaning animal holding facilities). Wildlife may act as reservoir hosts, so attempts should be made to exclude them from farms (using barriers, diverting migration routes), reduce their numbers (hunting, trapping, vermin control) or treat them (via medicated supplementary feeds or self-treatment devices such as rubbing posts or rollers). Several mathematical prediction models have been developed to help producers schedule interventions based on analyses of multiple bionomic factors, including climate (temperature, moisture, rainfall, photoperiod), location (longitude, latitude, elevation), vegetation (type, structure), land-use and animal husbandry (stocking rates, grazing histories). People most at risk of infestation may adopt personal protective measures by wearing better clothing (boots, socks, light-coloured trousers gathered or taped at cuffs, long-sleeved shirts), applying repellents to their skin or clothing (such as diethyltoluamide (DEET), permethrin, picaridin, oil of eucalyptus), or simply avoiding tick-infested bushy habitats. Many countries have adopted public health education campaigns to inform the general public about the risks of tick infestations as well as the microbial diseases they may carry.

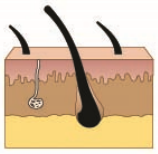
Dermacentor



Hosts
(mammals,
birds,
reptiles)

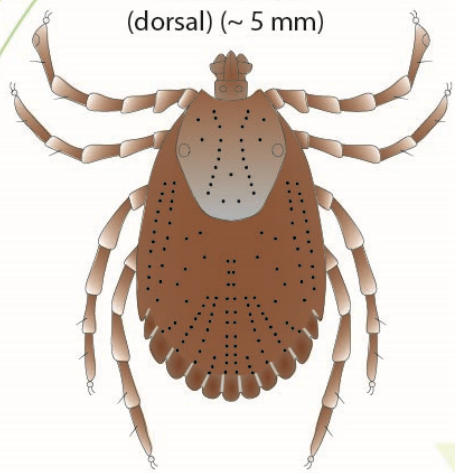
engorged female
(dorsal) (~ 10 mm)





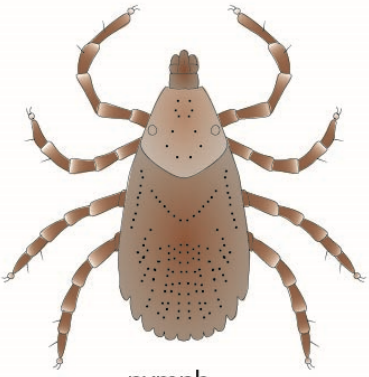
skin
(blood loss,
lesions,
toxicosis)
(vectors for
infectious
microbial
diseases)

adult female
(dorsal) (~ 5 mm)

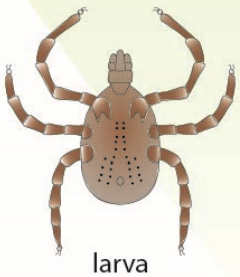


eggs laid in
soil/humus

eggs
(~ 0.5 mm)



nymph
(dorsal)
(~ 2 mm)



larva
(ventral)
(~ 0.6 mm)

hatch

questing
(host-seeking)

motile stages
(i.e. larvae (L),
nymphs (N) &
adults (A)) are
transient ecto-
parasites on
vertebrates
(feed on blood)

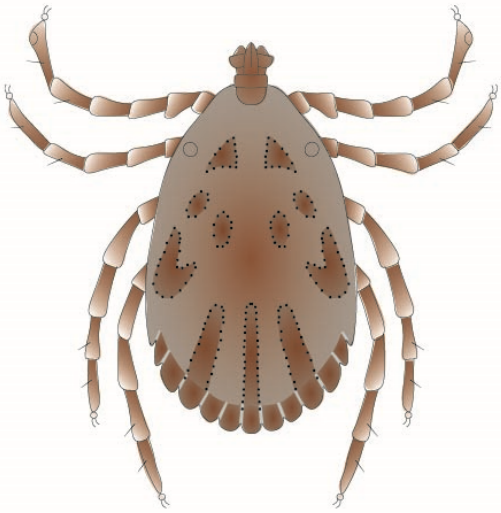
1
3

most *Dermacentor* spp. have 3-host cycles,
although some have 1-host cycles

{ 1-host cycle (LNA on same host)
3-host cycle (L-N-A on separate hosts)

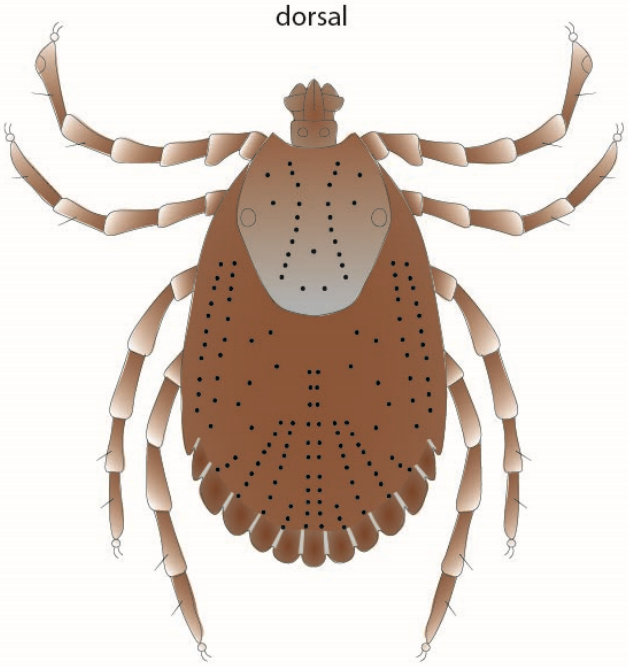
Dermacentor

dorsal



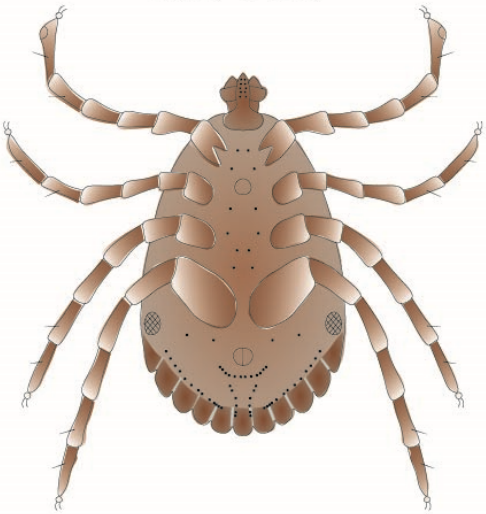
male (~ 3 mm)

dorsal

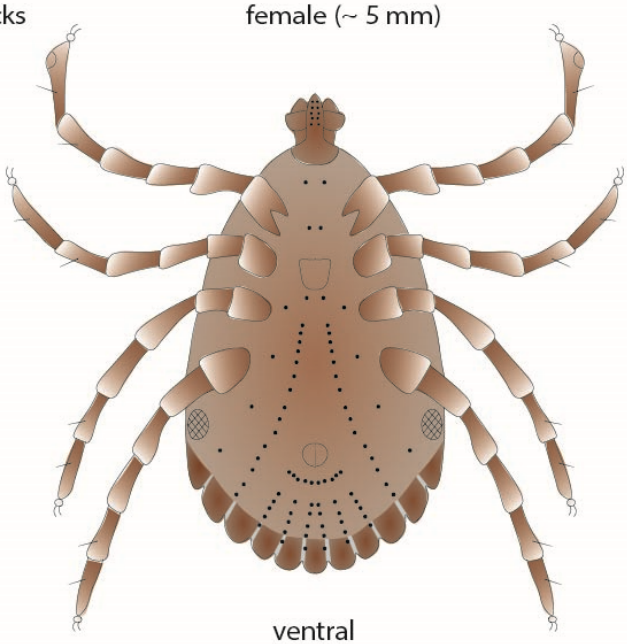


female (~ 5 mm)

adult ticks

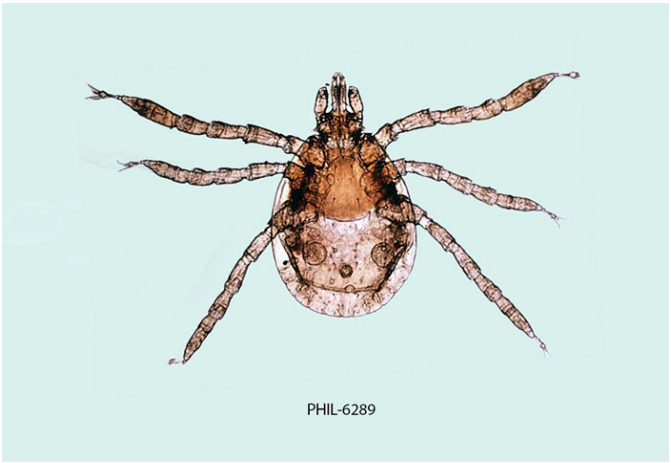


ventral

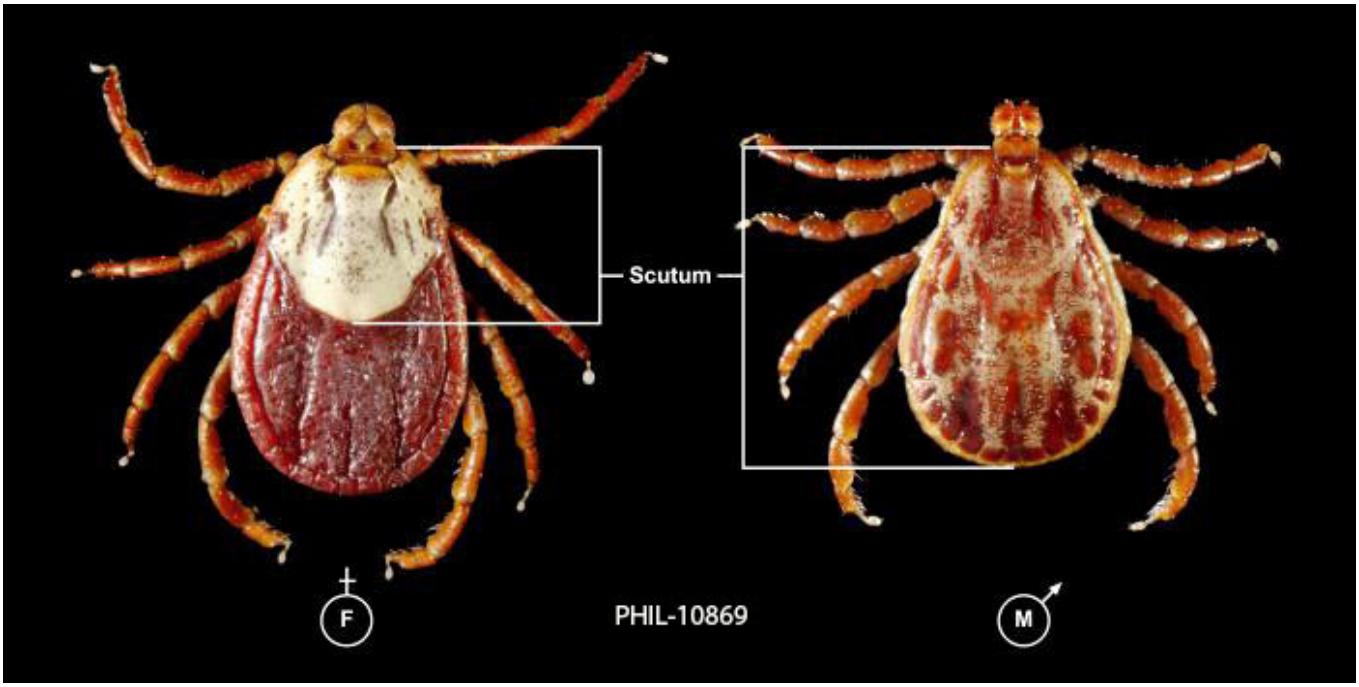


ventral

Dermacentor adult



Dermacentor larva



Dermacentor adults