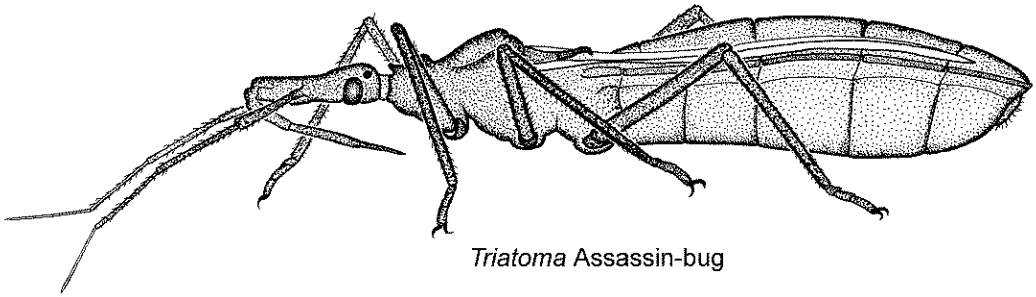
Parasitic Insects, Mites and Ticks

Genera of Medical and Veterinary Importance

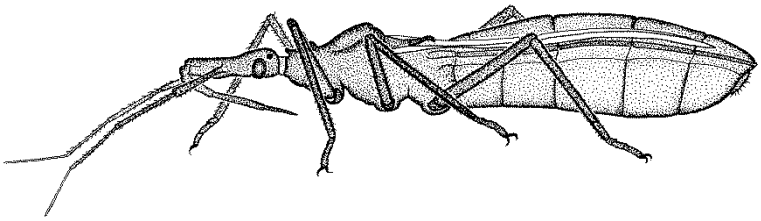
www.wikibooks.org



Triatoma Assassin-bug

Contents

Introduction



The largest blood-sucking parasite of this book, an Assassin-bug, genus *Triatoma*. They infest houses, and when feeding on inhabitants transmit the protozoan *Trypanosoma cruzi*, causative agent of Chaga's disease. There are schemes to eradicate these insects to improve welfare of humans.

Purpose

The purpose of this book is to provide an overview of insects, mites and ticks that directly cause diseases of humans and domestic animals, and that transmit organisms causing disease. This book is aimed at those students and practitioners in medical and veterinary health services, and associated biologists and researchers, who need to know about parasites. This information is provided to supplement current text-books of medical and veterinary parasitology. These textbooks typically provide information in chapters on physiology, reproduction, ecology, taxononomy, and so on. In contrast this book provides information mainly by detailed illustrations. These are provided for important genera, across the range of those important for health of humans and domestic animals.

The illustrations can also be used as aids for identification to genus level. Examples are given in the text of species, but care should be taken not to use this to over-identify to species level using this book. The criteria for inclusion in this book are those organisms usually taught in courses of medical/veterinary parasitology and dermatology, and of biological parasitology. The laboratory and clinical sessions of such courses may find this book of particular use.

This book is structured to serve as a framework on which further content and edits can easily be contributed. The building block of a genus should provide the flexibility needed to develop a book for laboratory use that will supplement standard textbooks. Please feel free to join the development of this Wikibook at www.wikibooks.org.

Format

Each representative genus is illustrated by a line drawing, with labelled features that are characteristic. All line drawings were made both by direct observation of representative specimens from various collections, and supported by consultation of many published illustrations. Contextual information is briefly provided on typical hosts, disease associations, and

also distribution where a useful general statement can be made of a restricted range. Glossaries are provided by chapters. They provide information in a progression through the book, so readers will need some cross-referencing; also there is deliberate repetition of some key words and concepts in various glossaries.

The emphasis of this book is necessarily at the level of genera of parasites so that a flexible overview of the whole subject can be provided. The number of species within these genera is too large to contain in any single book. General information is presented to assist readers in understanding how these parasites live, consisting of diagrams of life-cycles and of the relation of these parasites to skin of their hosts.[1]

Supporting information

More detailed information about the biology and relationships to direct parasitic disease or to transmission of pathogenic microbes should be sought in those modern textbooks in the References sections of each chapter, also in Wikipedia articles about individual species, or types of disease.[2,3,4,5,6,7,8] Effective photographs of many of these organisms are available from WikiCommons, and Wikipedia provides many additional articles.

All of the genera described are within the phylum Arthropoda. That is: bilaterally symmetrical invertebrate animals with an external skeleton, numerous limbs with many joints, and with either a clearly segmented body, or with evidence of segmentation during evolutionary history. The genera of relevance to medical and veterinary research and clinical care are the parasitic (or allergenic) forms. They divide into two major groups: the insects (lice, fleas, flies, and blood-sucking bugs) and the acarines (mites, soft ticks, and hard ticks). The important anatomical and physiological differences between insects and acarines are emphasized. Arthropods that are important because of their venom are covered elsewhere by other specialist publications.[9] The naming of parasites in this book follows published listings.[10,11,12]

The forms of parasitism described are mostly by feeding on blood or other body liquids taken in by the arthropod through the host's skin. This is called ectoparasitism: the parasite feeds at the surface of its host.[13] Some of the parasites burrow within the skin or deeper tissues, and some inhabit organs such as air-sacs or lungs. This is a form of endoparasitism, but note that this term used in the field of parasitology usually implies the helminth worms (nematodes, tapeworms and flukes). Also included in this book are those mites that cause allergies in humans and domestic animals whilst not being parasitic on them.

Classification

The list below is a simplified overview of the relationships between the groups of arthropods with genera and species of importance to medical and

veterinary parasitology, down to level of Family. The taxonomy of these arthropods has areas of continuing variation and controversy; no definitive statement of arthropod taxonomy is intended by this list. This book is an aid to clinical work, not a text about taxonomy.

Insecta (Class)

Phthiraptera (Order)
- Anoplura (sub-Order) Sucking lice
- Ischnocera (sub-Order) Chewing lice
- Amblycera (sub-Order) Chewing lice

Siphonaptera (Order)
- Pulicidae (Family) Cat fleas
- Ceratophyllidae (Family) Chicken-fleas

Diptera (Order)
- Nematocera (sub-Order)
  - Culicidae (Family) Mosquitoes
  - Ceratopogonidae (Family) Midges
  - Psychodidae (Family) Sandflies
  - Simuliidae (Family) Blackflies
- Brachycera (sub-Order)
  - Tabanidae (Family) Horse-flies
  - Muscidae (Family) House-flies, etc.
  - Calliphoridae (Family) Blowflies
  - Glossinidae (Family) Tsetse-flies
  - Oestridae (Family) Bot-flies
  - Hippoboscidae (Family) Louse-flies

Hemiptera (Order)
- Reduviidae (Family) Assassin-bugs
- Cimicidae (Family) Bed-bugs

Arachnida (Class)

Acarina (or Acari) (Order)
- Astigmata (sub-Order)
  - Sarcoptidae (Family) Sarcoptic mites
  - Psoroptidae (Family) Psoroptic mites
  - Cytoditidae (Family) Air-sac mites
  - Laminosioptes (Family) Cyst-mites
  - Analgidae (Family) Feather-mites
  - Acaridae (Family) Grain-mites
- Prostigmata (sub-Order)
  - Demodicidae (Family) Hair-follicle mites
  - Cheyletiellidae (Family) Fur-mites
  - Trombiculidae (Family) Trombiculids
- Mesostigmata (sub-order)
  - Dermanyssidae (Family) Bird mites
  - Macronyssidae (Family) Bird mites
- Ixodida (sub-Order)
  - Argasidae (Family) Soft-ticks
  - Ixodidae (Family) Hard-ticks

The hierarchy of classification of animals goes: Phylum> Class> Order> Family>Genus and finally the name of a physical living organism given as the unique combination of the genus to which it belongs and its own species name. For example: *Haematopinus suis* always written in italic script (also known in English as the Hog-louse).

[to Contents]

About this book

The person who started this Wikibook wishes to be anonymous to encourage contributions from other people. This book is already a collaboration because it has depended on loans of specimens to draw and photograph, on help of colleagues, and on the accumulated knowledge that is written in the textbooks and research papers, as seen in the reference lists of this book. All those people within the fields of medical and veterinary entomology are acknowledged and thanked.

References

1. Alexander, J.O'D. (1984) *Arthropods and Human Skin*. Germany, Springer Verlag.
2. Russell, R.C., Otranto, D. & Wall, R.L. (2013) *Encyclopedia of Medical and Veterinary Entomology*. Wallingford & Boston: CABI, ISBN 978-1-78064-037-2.
3. Zajac, A. & Conboy, G.A. (2012) *Veterinary Clinical Parasitology*. Chichester: Wiley–Blackwell, ISBN 9780-8138-2053-8.
4. Mullen G. & Durden L. (2009) *Medical and Veterinary Entomology*. (2nd ed.). New York: Academic Press. pp. 423–482. ISBN 978-0-12-372500-4.
5. Taylor, M.A.; Coop R.L.; Wall, R.L. (2007) *Veterinary Parasitology*. Oxford: Blackwell Publishing, ISBN 978-1-4051-1964-1.
6. Kettle, D.S. (1995). *Medical and Veterinary Entomology*. Wallingford: CAB International. ISBN 0-85198-968-3.
7. Bowman, D.D. (2009) *Georgi's Parasitology for Veterinarians*. St. Louis: Saunders / Elsevier, ISBN 978-1-4160-4412-3.
8. Hendrix, C.M. & Robinson, E. (2011). *Diagnostic Parasitology for Veterinary Technicians*. St. Louis: Mosby / Elsevier, ISBN 0-323-0776-17.
9. Peters, W. (1992) *A Colour Atlas of Arthropods in Clinical Medicine*. Wolfe Publishing Ltd. London.
10. Ashford, R.W. & Crewe, W. (1998) *The Parasites of Homo sapiens: an Annotated Checklist of the Protozoa, Helminths and Arthropods for Which We Are Prone*. Liverpool, Liverpool School of Tropical Medicine. ISBN 0-9508756-9-4.
11. Pittaway, A.R. (1991) *Arthropods of Veterinary Importance: a Checklist of Preferred Names and Allied Terms*. Wallingford, England, CABI Publishing, ISBN 0-85198-741-9.
12. Guglielmone, A.A., et al. (2014) *The Hard Ticks of the World*. Heidelberg, Springer. ISBN 978-94-007-7497-1.
13. Scott, D.W. (1988) *Large Animal Dermatology* (chapter 9). Philadelphia, W.B.Saunders Company. ISBN 0-7216-8553-6.

Insects: general characters

Characters of parasitic insects (Insecta) of veterinary and medical importance

[to Contents]

There are four Orders (a major taxonomic grouping) of insects with species of medical and veterinary importance: lice (Phthiraptera), fleas (Siphonaptera), two-winged flies (Diptera), sucking bugs (Hemiptera). The insects separated from the acarines (mites and ticks) very early during evolution and need to be considered separately, despite the words 'insect' or 'bug' sometimes being used to include mites and ticks.

The body consists of a series of structurally similar segments, and most of these are clearly visible. Segments of adult insects are distinctly grouped into: head, thorax, and abdomen. The head bears a pair of antennae to sense smells, and usually a pair of eyes.

Complex mouthparts are borne on the head. These include piercing tubes made of many separate cutting parts, and sometimes a sponge-like organ (labella) to collect liquid food. A pair of palps is used to sense food sources.

The thorax consists of three segments, each of which bears a pair of legs with many joints. In the two-winged flies (Diptera) the middle thoracic segment bears a pair of wings, and the posterior segment bears a pair of halteres. The halteres were by evolution derived from wings and assist the insect to fly.

There are two types of life-cycle of these insects. These are illustrated for lice and for two-winged flies. To develop from egg to adult all arthropods need to shed repeatedly their old exoskeleton to permit further growth and then mature a larger exoskeleton. The transition from one stage of growth of the exoskeleton to the next is a molt. These stages are also called instars.

[to Contents]

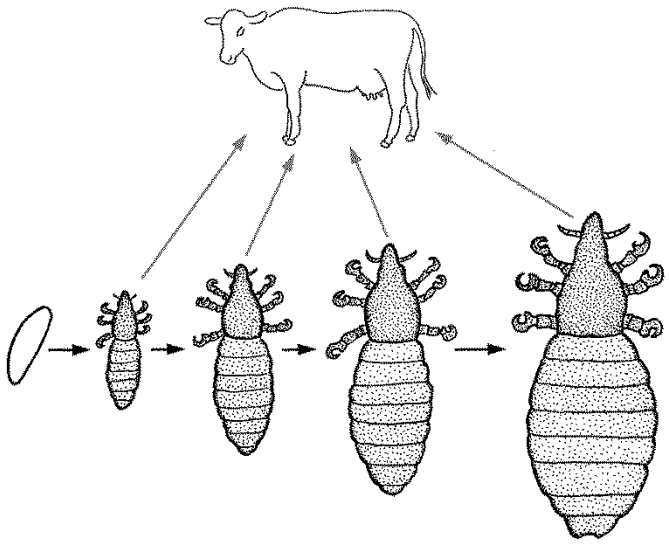


Diagram of lice feeding on a cow is an example of a parasitic insect life-cycle with incomplete metamorphosis (a transformation of morphology and physiology). Lice develop from egg to first nymph stage then several more nymph stages, and finally to a mature adult, either female or male. These larvae and nymphs closely resemble the adults in structure and behavior. In this example all nymphs and adult feed parasitically.

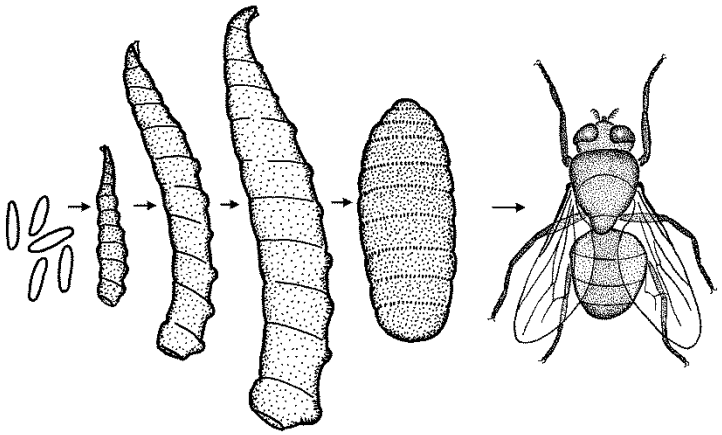


Diagram of fly maggots and adults is an example of a parasitic insect life-cycle with complete metamorphosis, using example of two-winged flies. Fleas and two-winged flies develop from egg to first larva stage. The larva is worm-like, legless and clearly segmented, and behaves differently from the adult. The larva typically goes through two or three more molts. When the larva is fully grown it transforms into a pupa. Within the outer case of the pupa a complete metamorphosis occurs. The pupa transforms into an adult female or male then emerges from the case. In this example either the larvae or the adult may feed parasitically.[1,2,3]

Glossary

- Antenna = Paired organs protruding from head that sense odors (see Mosquitoes and similar).
- Exoskeleton = The external skeleton of insects, acarines, and similar animals.
- Instar = Another term for a stage in the life-cycle of insects and acarines.
- Labella = A single component of the mouthparts of insects, may be sponging or piercing (see Mosquitoes and similar)
- Metamorphosis = A change in the size and/or form of an insect or acarine.
- Molt = Shedding of exoskeleton to permit growth from one stage of life-cycle to next.
- Order = A major taxonomic grouping, between class and family (see Introduction).
- Segment = Many invertebrate animals are basically composed of many similar functional units called segments. Insects are clearly segmented, but segmentation in acarines is obscure.

References

1. Service, M.W. (1980) *A Guide to Medical Entomology*. London, The Macmillan Press Ltd. ISBN 0-333-23381-6.
2. Marshall, A.G. (1981) *The Ecology of Ectoparasitic Insects*. New York, Academic Press, ISBN 0-12-474080-4.
3. Lehane, M.J. (1991) *The Biology of Blood-sucking Insects*. London, Harper Collins, ISBN 0-04-445409-0.

Lice

Characters of lice (Phthiraptera)

[to Contents]

Photograph shows a sucking louse, genus *Pediculus*, the Head-louse that infests scalp of humans. Note size of louse against the hairs. Photograph by Gilles San Martin

Lice are insects that live as obligate parasites; that is, they are all so specialized that they can only feed and develop as parasites. Each feeding stage of the life-cycle takes repeated small meals. Lice are flattened dorso-ventrally, and never develop wings. On their hosts lice show a dull surface and are colored from pale yellow through to dark brown.

Lice live entirely on their hosts; they crawl from one individual host to another when hosts are in close contact. Some species are able to survive for

a short time off their host. Females attach their eggs in rows onto hairs or feathers of their hosts. These glued eggs are called nits and are easily recognized as a sign of louse infestation. Lice steadily lay small batches of large eggs and their survival rate is high as they develop into nymphs. This good survival enables louse infestations to increase to high densities per host under favourable conditions, typically when hosts are housed close together for long periods. However, sparse infestations by lice typically cause little or no signs of disease.

Each species of louse is specialized for feeding on one species of host, or on a few closely related species. This permits specific adaptations for digestion of blood and evasions of immune reactions by their hosts. These associations also simplify identification of these parasites. The Order Phthiraptera is thought to have multiple origins, making their classification difficult and varied. (Older groupings of the lice included the blood-sucking Siphunculata and the skin-chewing Mallophaga). However, lice converged during evolution, and for clinical purposes are easily grouped into those specialized to suck blood (sub-order Anoplura), and those specialized to chew on skin scales, hair or feathers. There are two sub-orders of chewing lice, the Amblycera and the Ischnocera.[1,2,3,4]

Glossary

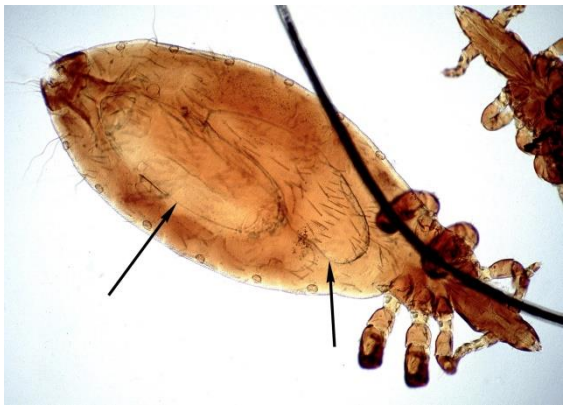
- Abdomen = Posterior part of body of insects, containing gut, gonads and other organs.
- Bristle = A large thick type of seta (6 on *Pediculus*).
- Claw = Legs of most insects and acarines end in hard sharp gripping organs (5 on *Haematopinus*).
- Eye = Most insects have prominent eyes on their head, either compound eyes of many sensory units, or simple eyes of one sensory unit (2 on *Pediculus*).
- Granuloma = Scar tissue, as often forms in skin where an insect or acarine has fed and made an inflamed wound.
- Nit = Vernacular and clinical term for egg of a louse glued to hair or feathers of host (10 on *Haematopinus*).
- Obligate = A form of parasitism where the parasite can only feed parasitically, in contrast to facultative parasitism where the animal can optionally feed in a free-living or non-parasitic way.
- Paratergal plate = Hardened (sclerotized) plates on the lateral margins of abdominal segments of some lice (5 on *Pediculus*).
- Pediculosis = Clinical term for the disease state of heavy infestation with lice.
- Pruritus = Itching.
- Seta = A pivoted moveable extension of the body wall of insects and acarines (5 on *Solenopotes*).
- Sclerotize = When part of the body wall of an insect or acarine becomes tanned and harder than surrounding areas.
- Spiracle = Opening in body wall to allow respiration (4 on *Pthirus*).

• Sternal plate = A sclerotized part of the body wall on the ventral surface of a louse (8 on *Linognathus*).
• Sucking = This term is used to distinguish the anopluran lice, which suck up blood from their hosts with needle-like mouthparts, from the amblyceran and ischnoceran chewing lice, which have no blood-sucking mouthparts (see Chewing lice).
• Tubercle = A hump shaped protrusion of the body wall (4 on *Pthirus*).

Characters of Sucking lice (Anoplura)

[to Contents]

Mouthparts are thin and long for piercing, and are retracted when not in use. There are no sensory palps. Antennae usually have five segments. The thorax has three segments fused so their divisions are unclear. Spiracles are usually visible dorsally; a pair on the thorax and one at each side of most abdominal segments. Eyes occur on some species, as a pair on their head. These lice parasitize many species of mammals.



Photograph shows a female *Linognathus* louse from an infestation on cattle, showing gripping of host hair, and outlines of two eggs (arrowed). Note that the mouthparts of sucking lice are retracted within the head between sessions of blood feeding.

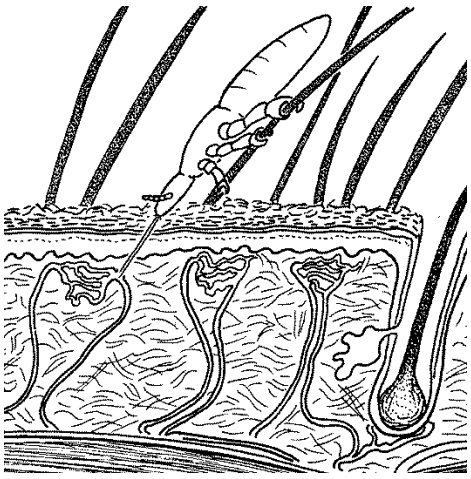
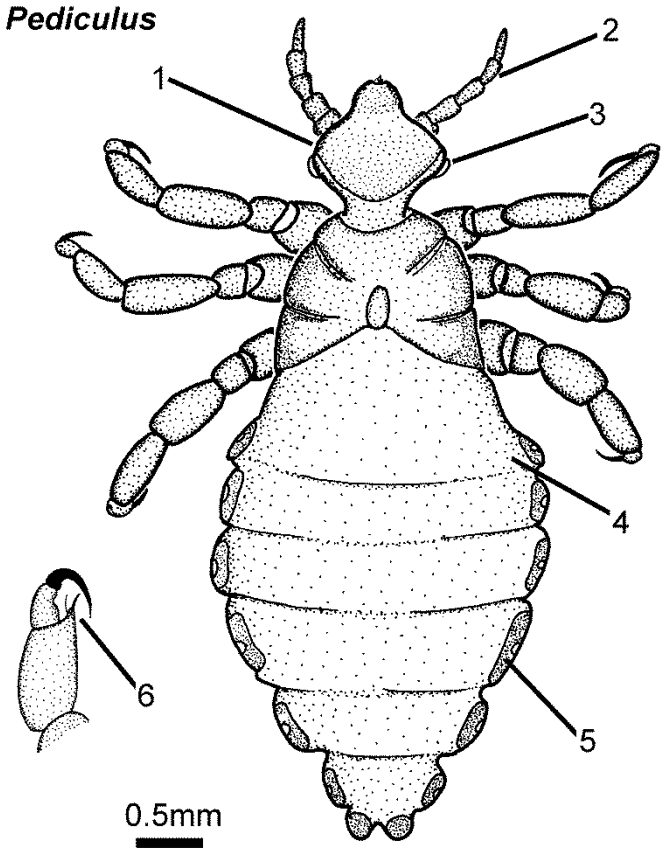


Diagram of feeding at skin shows a typical sucking louse penetrating dermal capillaries of host with long fine mouthparts (proportions of louse to skin are not drawn accurately).

Pediculus (Pediculidae, Sucking lice)

[to Contents]



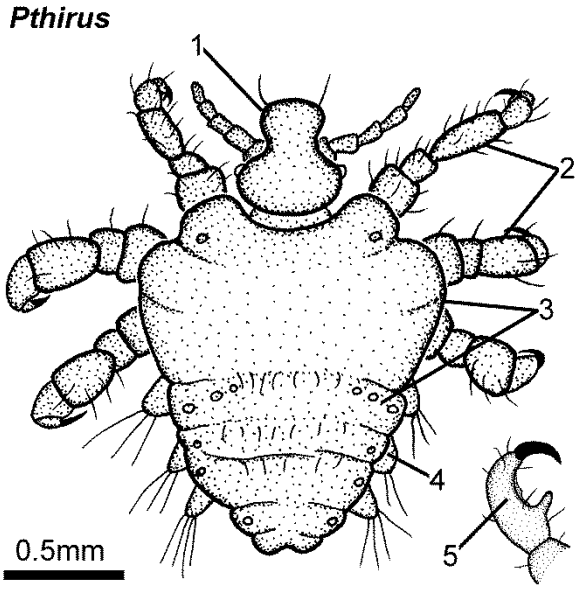
Characters: female, dorsal. 1- Width of head is equal to its length. 2- Antenna has 5 segments. 3- Eyes are prominent. 4- Abdomen is elongate, bulging centrally. 5- Abdominal paratergal plates are prominent. 6- Tibial spurs have small bristles.

Hosts: The two species (or sub-species) *P.humanus humanus* the Body-louse, and *P.humanus capitis* the Head-louse, parasitize only humans.[5,6]
Signs and symptoms: Body-lice reside and lay their eggs on clothing of humans. They crawl onto their host's skin to feed on blood, resulting in small localized inflamed and pruritic sites. Chronic heavy infestations lead to a thickening and added pigmentation of the skin. Head-lice reside in the hair of the head and lay eggs (known as nits) on those hairs. These eggs or their empty cases are the most easily seen sign of infestation. Inflammation and pruritus result from these lice feeding. Infestations of humans by Body-lice are commonest either on individuals living in severe poverty, or on larger groups of people forced to crowd together under conditions of social collapse, warfare or refugee camps.[7]
Disease: The Head-louse is not known to transmit any pathogens. Heavy infestations of the Body-louse cause the condition is known as pediculosis, experienced literally as feeling lousy. The Body-louse transmits to humans three species of bacteria: *Rickettsia prowazekii* causing epidemic or louse-

borne typhus[8] ; *Bartonella* (formerly *Rochalimaea*) *quintana* causing trench fever [9]; and *Borrellia recurrentis* causing louse-borne relapsing fever.[10]

Pthirus (Pthiridae, Sucking lice)

[to Contents]

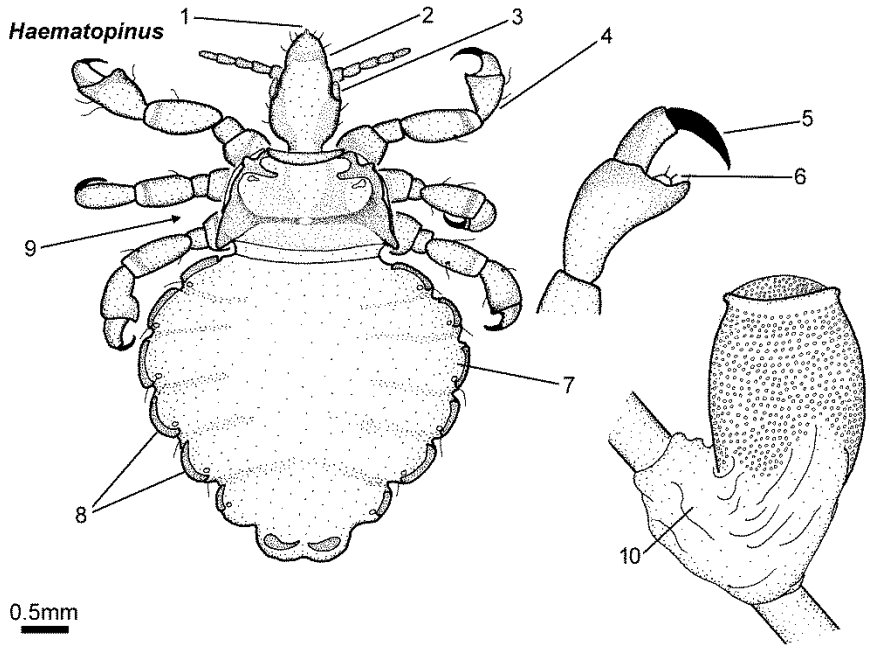


Characters: female, dorsal. 1- Head is blunt anteriorly; eyes are present. 2- Fore-legs are thin; mid- and hind-legs are stout. 3- Thorax is wide whilst abdomen is narrow and short. 4- Abdomen bears lateral tubercles and dorsal spiracles. 5- Mid- and hind-legs have large claws which close onto a tibial spur.

Hosts: The human Pubic-louse or Crab-louse, *P. pubis*, is specific for humans. The other single species of this genus is specific for gorillas.
Symptoms and disease: Infestations are usually confined to pubic hair but hair in axillae, eyebrows and beard may become infested. Pruritus is the commonest symptom of infestation but spots of grey pigmentation of skin may occur where there is chronic infestation. *Pthirus pubis* is not a vector of pathogens.[11]

[Continued]

Haematopinus (Haematopinidae, Sucking lice) [to Contents]



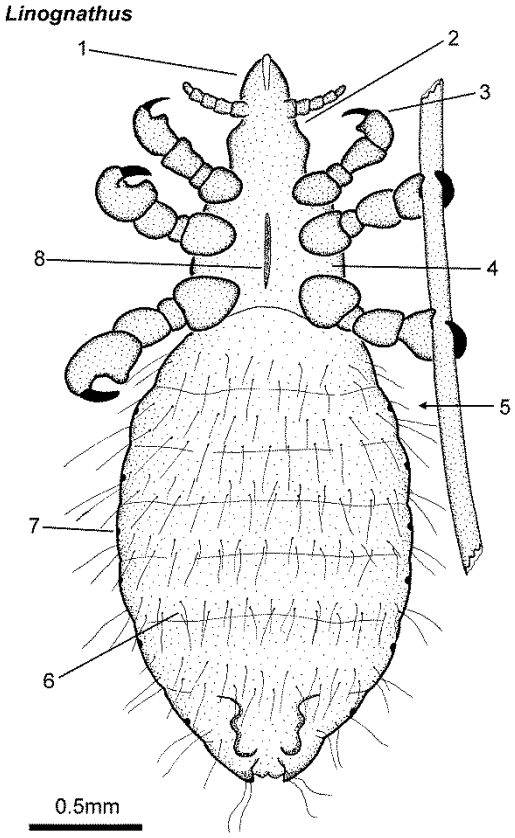
Characters: female, dorsal, claw and egg. 1- Point at which mouthparts protrude when in use. 2- Head is elongate. 3- Eyes are absent, but there is an ocular point posterior to the antenna. 4- All legs are of similar size. 5- All legs bear a large claw that closes onto a tibial spur. 6- Next to the tibial spur is a tibial pad. 7- Abdominal segments bulge laterally. 8- Abdominal segments bear hardened (sclerotized) paratergal plates. 9- Body is large with distinct brown areas. 10- Egg glued by a female onto a hair of its host. Also: sternal plate on ventral side of thorax is large and dark.

Hosts: The only species of louse found on pigs is *Haematopinus suis* (Hog-louse); infesting the neck, flanks and insides of legs. Horses and other equids are infested by *H. asini* on their head, neck, back, brisket and between legs. Cattle are infested by *H. eurysternus* (Short-nosed louse) which occurs all over the body, and *H. quadripertusus* (Tail-louse) which infests the tail.

Signs: These lice cause irritation, pruritus, and dermal granulomas.

Disease: Piglets may suffer severe anemia if heavily infested. Biting-stress and lost production in pigs and cattle is caused. Also economically significant losses to processors of leather hides may be caused by dermal granulomas at the feeding sites of these large lice.[12]

Linognathus (Linognathidae, Sucking lice) [to Contents]



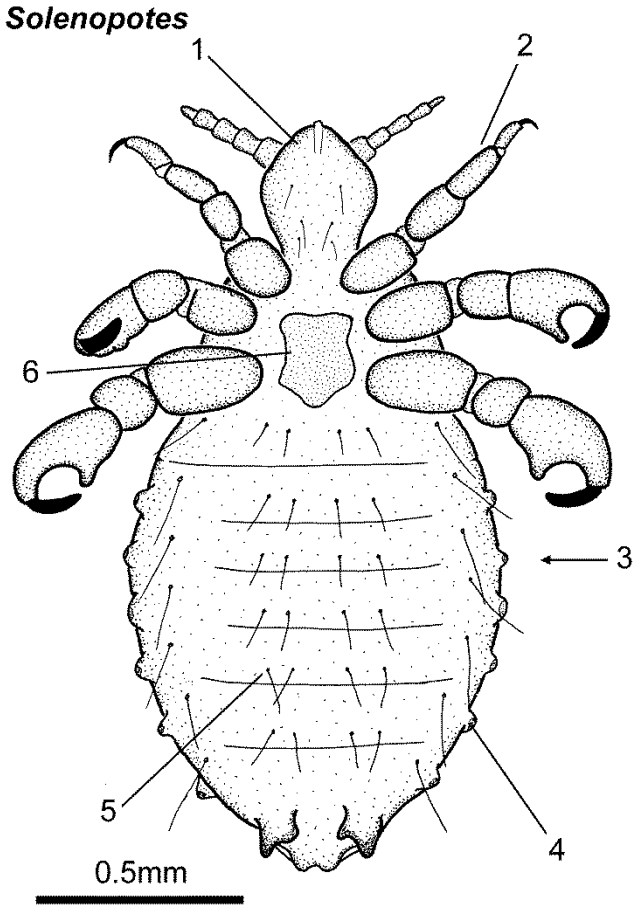
Characters: female, ventral. 1- Head is usually elongate. 2- There is no ocular point posterior to the antenna. 3- Fore-legs are smaller than the mid- and hind-legs; claw on the fore-leg forms a smaller gripping mechanism than on the mid- and hind-legs. 4- Body is dark grey and these lice are medium sized. 5- Each segment of the abdomen bears two rows of setae. 6- Abdomen is without paratergal plates. 7- Sternal plate on ventral surface of thorax is narrow or absent.

Hosts: Cattle are infested by *Linognathus vituli* (Long-nosed cattle louse) on their head, thorax and abdomen. Sheep are similarly infested by *L. ovillus* (Blue louse), whilst *L. pedalis* infests feet of sheep. Dogs are infested by *L. setosus* and goats by *L. stenopsis*.

Signs: Irritation, pruritus, dermal granulomas, and dermal induration are caused. Heavy infestations lead to the hair-coat having a lousy appearance: matted, staring and dull. Sheep infested with *L. ovillus* may lose areas of wool due to combination of inflammation and persistent self-grooming. (Note that the feeding of these and similar lice does not result in the disruption and heavy scabbing of the skin surface that is the main sign of infestation with psoroptic scab mites. Inspection by eye reveals intact skin even when louse infestations are fairly heavy.)

Disease: Heavy infestation causes biting-stress, and anemia leads to loss of production. Hides for leather manufacture are damaged by granuloma formation at feeding sites of these lice.[13]

Solenopotes (Linognathidae, Sucking lice) [to Contents]



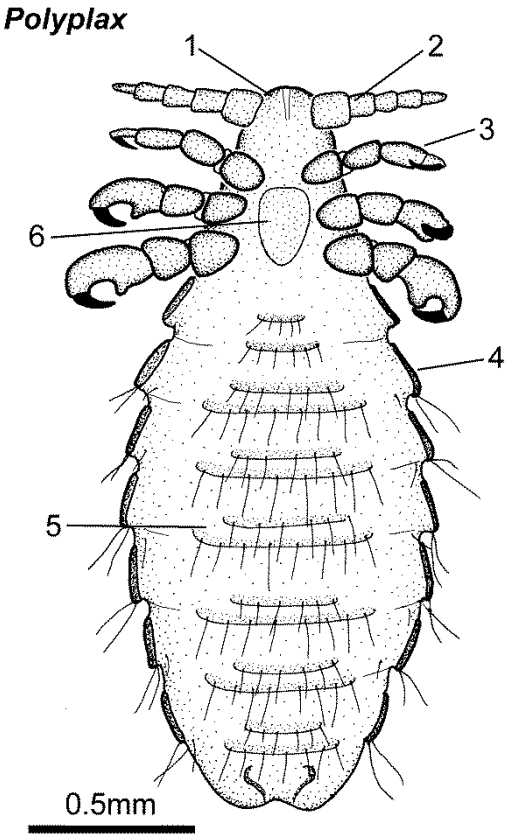
Characters: female, ventral. 1- Head is without eyes and ocular points, and has a blunt profile. 2- Fore-legs are smaller than the mid-legs and hind-legs; they lack a tibial spur. 3- Abdomen is without paratergal plates. 4- abdominal spiracles are borne on tubercles. 5- Abdominal segments bear one row of setae. 6- Sternal plate on the ventral surface of thorax is large and dark. Also: body is small and grey.

Hosts: Cattle are infested by *Solenopotes capillatus* (Little blue louse) on their head, neck, shoulders, back and tail.

Signs and disease: Irritation and pruritus, and the signs listed above for *Linognathus* are caused. Effects on host are similar to those for *Linognathus* but this smaller louse is less likely to cause lousiness.[14]

Polyplax (Polyplacidae, Sucking lice)

[to Contents]



Characters: female, ventral. 1- Head is short and blunt; eyes and ocular points are absent. 2- Antennae are large relative to size of head. 3- Fore-legs are small relative to mid- and hind-legs; they have no tibial spurs. 4- paratergal plates are present on the abdomen. 5- Abdominal segments bear two rows of setae. 6- Sternal plate on ventral surface of thorax is large. Also: body is small.

Hosts and Disease: Lice of this genus infest rodents. Such infestations may become a problem to pet rodents and in laboratory colonies.

References

1. Ledger, J.A. (1980) *The Arthropod Parasites of Vertebrates in Africa south of the Sahara*. Vol. IV Phthiraptera (Insecta). Johannesburg, South African Institute for Medical Research.
2. Lane, R.P. & Crosskey, R.W. (eds) (1993) *Medical Insects and Arachnids*. London, Chapman & Hall. ISBN 0-412-40000-6.
3. Lancaster, J.L. & Meisch, M.V. (1986) *Arthropods in Livestock and Poultry Production*. Chichester: Ellis Horwood Ltd. ISBN 0-85312-790-5.
4. Price, M.A. & Graham, O.H. (1997) *Chewing and Sucking Lice as Parasites of Mammals and Birds*. Technical Bulletin 1849, Washington D.C., United States Department of Agriculture.
5. Olds B.P., et al. (2012) Comparison of the transcriptional profiles of head and body lice. Insect Molecular Biology 21: 257–68.

6. Yong, Z., et al. (2003) The geographical segregation of human lice preceded that of *Pediculus humanus capitis* and *Pediculus humanus humanus*, Comptes Rendues Biologies, 326: 565–574.
7. Buxton, P.A. (1947) *The Louse; an Account of the Lice which Infest Man, their Medical Importance and Control* (2nd ed.). London: Edward Arnold.
8. McDade, J.E., et al. (1980) Evidence of *Rickettsia prowazekii* infections in the United States. The American Journal of Tropical Medicine and Hygiene, 29: 277-284.
9. Brouqui, P.; Bernard Lascola, B. et al. (1999) Chronic *Bartonella quintana* bacteremia in homeless patients. New England Journal of Medicine, 340:184-189. DOI: 10.1056.
10. Cutler, S.J., et al. (1997) *Borrelia recurrentis*: Characterization and comparison with Relapsing-Fever, Lyme-associated, and other *Borrelia* spp. International Journal of Systematic Bacteriology 47, 958-968.
11. Anderson, A.L. & Chaney, E. (2009) Pubic Lice (*Pthirus pubis*): History, biology and treatment vs. knowledge and beliefs of US college students. International Journal of Environmental Research and Public Health. 6: 592-600. DOI:10.3390/ijerph6020592.
12. Smith, H.M., et al. (1982) Parasitism among wild swine in the southeastern United States. Journal of the American Veterinary Medical Association, 181: 1281-1284.
13. Otter, A., et al. (2003) Anaemia and mortality in calves infested with the long-nosed sucking louse (*Linognathus vituli*) Veterinary Record, 153:176-179.
14. Grubbs, M.A.; Lloyd, J.E. & Kumar R. (2007) Life cycle details of *Solenopotes capillatus*. Journal of Economic Entomology, 100: 619-621.

Chewing lice

Characters of Chewing lice, sub-order Ischnocera [to Contents]

These lice have no blood-sucking mouthparts. They feed by chewing, using ventral mandibles like teeth. These mandibles also are used to grip onto hairs or feathers, and there is a groove in the ventral surface of the head to fit hairs or feather shafts. Palps are absent at the mouthparts.

Photograph shows an ischnoceran chewing louse, with the well developed ventral mouthparts arrowed.

[to Contents]

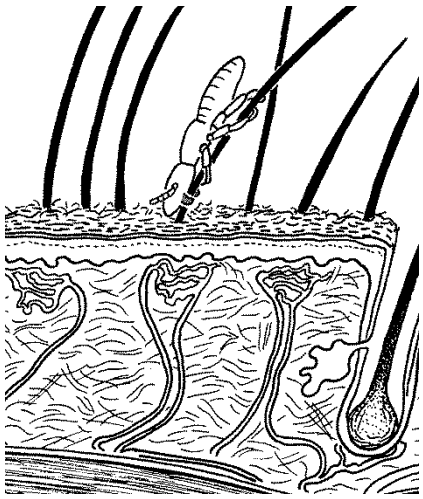


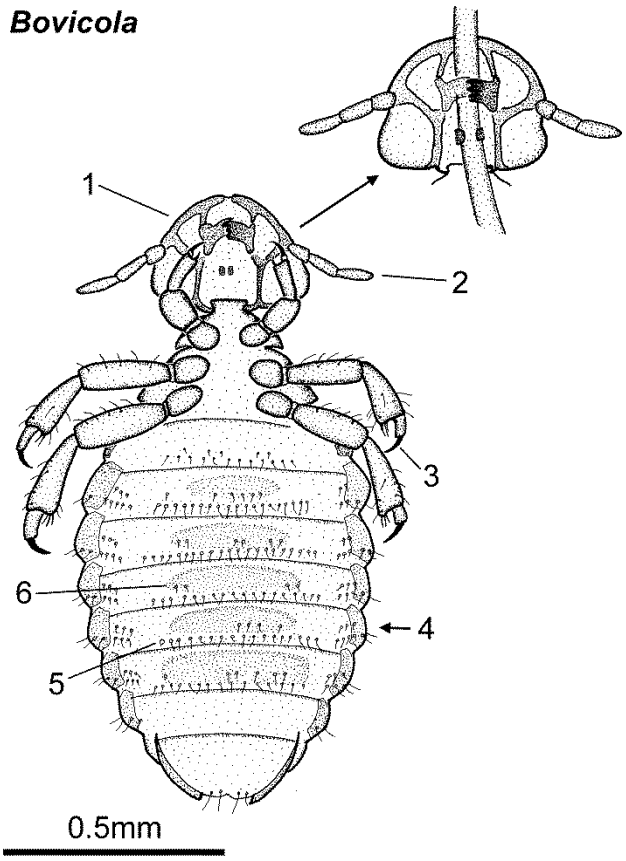
Diagram of feeding at skin represents an ischnoceran chewing louse on its host (proportions of louse to skin are not accurate).

The three segments of the thorax are fused together; the boundaries between them are indistinct. The ischnoceran lice that infest domestic animals are in two families. Those that infest mammals have antennae with three segments and legs with a single claw. Those that infest birds have antennae with five segments and legs with a pair of claws. The claws of the legs do not articulate onto a distinct tibial claw (as often seen in the sucking lice).

Glossary

- Chewing = The adjective 'biting' is often used as synonymous with 'chewing' and also 'sucking', as in 'biting-flies' meaning blood-sucking flies. Confusion is avoided in this book by not using biting in this sense. However, the familiar and obvious term 'biting-stress' is used here for the pruritus and pain caused to hosts by many ectoparasites (see Sucking lice).
- Intermediate host = Parasitological term for a host in the life-cycle of a parasite when the parasite passes passively to the definitive host through the environment or by the intermediate host being eaten by the definitive host. (Compare: insects and acarines carrying parasitic organisms between their feeding hosts are not intermediate hosts, they are vectors or transmitters because the organisms pass actively between hosts during feeding by the vector.)
- Mandible = A pair of grasping and grinding organs forming the main part of the mouthparts, like jaws (inset on figure for *Bovicola*)
- Palp = Paired, segmented, organs associated with the mouthparts, having sensory functions (2 on *Heterodoxus*).
- Sclerotization = Hardening of parts of the body wall by a process of tanning.
- Spine = A non-moveable sharp pointed extension of the body wall (see ventral head of *Heterodoxus*).

Bovicola (Trichodectidae, Chewing lice) [to Contents]
(also known as *Damalinia*)



Characters: female, ventral. 1- Head is short and blunt. 2- Antennae have three segments. 3- Legs have a single claw. 4- Abdomen has spiracles on the edge of the dorsal surface of segments 2 to 7. 5- Abdomen segments bear one row of short or medium setae, and other groups of setae. 6- Bands of brown sclerotization are distinct on abdominal segments. Inset: typical position of louse gripping host hair with its mouthparts. Also: body is small and light red/brown.

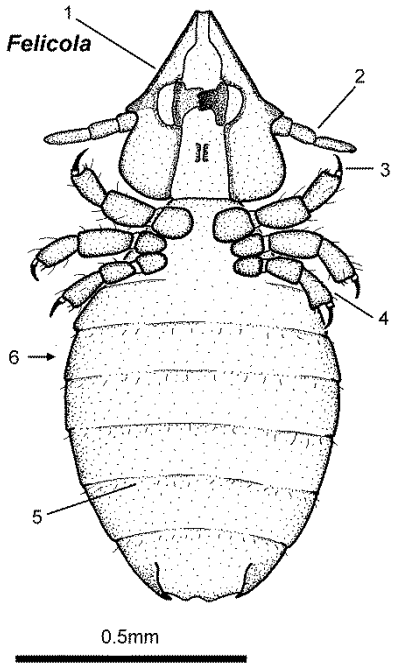
Hosts: *Bovicola bovis* (Red or chewing-louse of cattle) infests cattle on their neck, shoulders, back and rump. *Bovicola ovis* (Red or chewing-louse of sheep) infests sheep on their back and upper regions of their body; *B. caprae* (Red or chewing-louse of goats) infests goats; *B. equi* (Horse chewing-louse) infests horses.

Signs: Irritation and pruritus leads to restless self-grooming. (Note that in comparison to an infestation of sheep with psoroptic scab mites *Bovicola* lice do not directly cause the skin to form moist scabs, the surface of the skin will appear intact, although with heavy infestations self-grooming may damage the skin.)

Disease: Biting-stress leads to loss of production from heavy infestations. *Bovicola bovis* feeding activity can cause damage to the appearance of processed hides. This damage is known as spot and fleck. This occurs despite the superficial feeding of these lice.[1]

Felicola (Trichodectidae, Chewing lice)

[to contents]



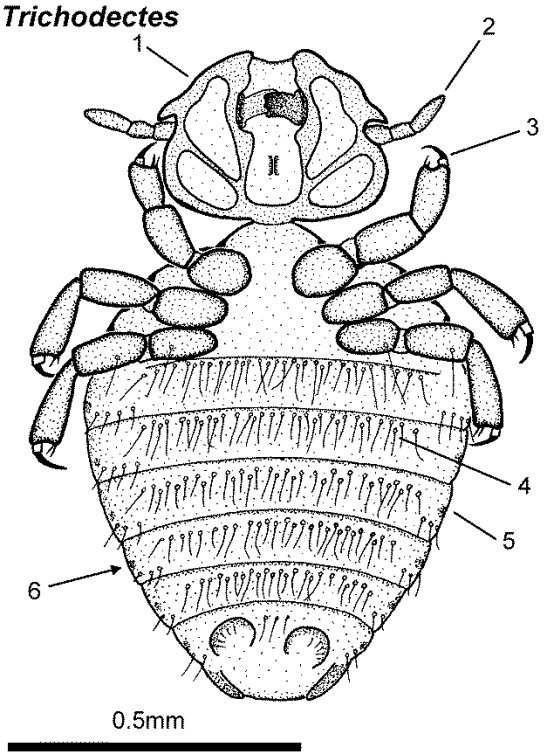
Characters: female, ventral. 1- Anterior part of head is elongated into a conical shape. 2- Antennae have three segments. 3- All legs have single claws. 4- Hind legs are smaller than fore- and mid-legs. 5- Abdomen has smooth appearance with a few short setae. 6- Dorsal surface of abdomen bears 3 pairs of spiracles. Also: body is small and pale yellow.

Hosts: *Felicola subrostrata* is the only species of louse likely to be found on domestic cats.

Signs and disease: Effective self-grooming seems to protect most cats from harmful levels of infestation. However, sick, very old cats, or long-hair breeds may suffer from their infestations with this louse.[2]

[Continued]

Trichodectes (Trichodectidae, Chewing lice) [to Contents]



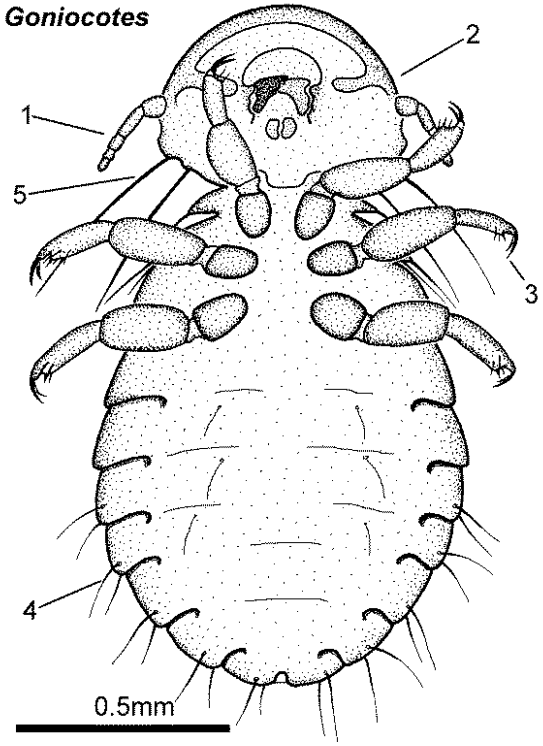
Characters: female, ventral. 1- Head is short and blunt. 2- Antennae have 3 segments. 3- Legs have a single claw. 4- Abdominal segments bear one dense row of long seta; similar setae are also on the legs. 5- Abdomen has a distinctly rounded shape. 6- Abdominal segments have spiracles on the edge of their dorsal surface. Also: body is small and pale yellow.

Hosts: *Trichodectes canis* (Dog chewing-louse) infests domestic dogs on their head, neck and tail. It also infests wild canids. This species may need to be distinguished from *Heterodoxus spiniger* on dogs in countries where both species of chewing lice occur.

Signs and disease: Heavy infestations produce irritation and biting-stress, leading to restlessness and much self-grooming. Such infestations lead to the hair-coat having a lousy appearance: matted, staring and dull. This louse is an intermediate host for the tapeworm of dogs, *Dipylidium caninum*. The dog becomes infected when it ingests infected lice that it has groomed off .[3]

Goniocotes (Philopteridae, Chewing lice)

[to Contents]



Characters: female, ventral. 1- Antennae consist of 5 segments. 2- Head and body have a compact rounded shape. 3- Legs each bear a pair of claws. 4- Long setae project from lateral margins of abdomen. 5- Posterior margin of head bears a pair of long stout setae (like bristles) on each side. Also: body is small and pale yellow.

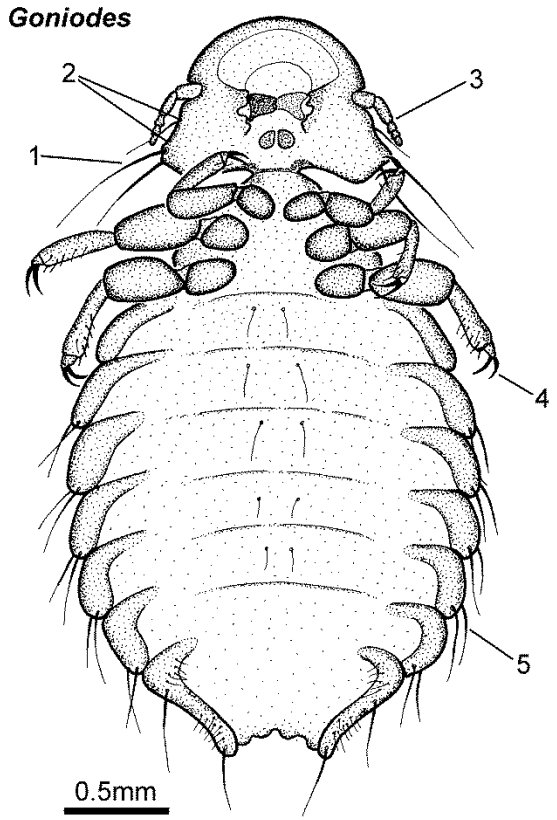
Hosts: *Goniocotes gallinae* (Fluff-louse) commonly infests poultry, amongst the down feathers over most of the body.

Signs and disease: Infestations are usually slight, but heavy infestations damage the plumage and cause restlessness leading to reduced productivity of poultry.[4]

[Continued]

Goniodes (Philopteridae, Chewing lice)

[to Contents]



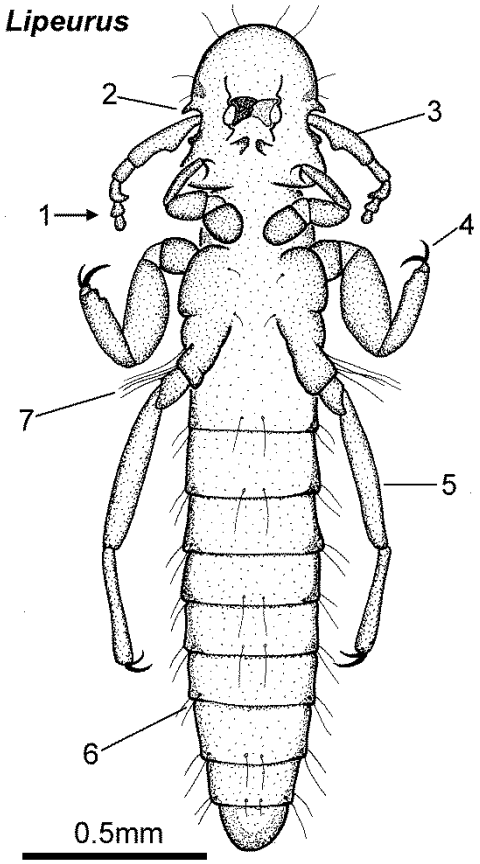
Characters: female, ventral. 1- Long setae are borne on the protruding angle at posterior of head. 2- Head is shaped distinctively with hollow margin and protruding angle posterior to the antennae. 3- Antenna consists of 5 segments. 4- Legs each bear a pair of claws. 5- Long setae project from the lateral margins of abdomen. Also: body is large and brown.

Hosts: *Gonoides dissimilis* (Brown chicken-louse) and *G. gigas* (Large chicken-louse) infests chickens, whilst *G. meleagridis* infests turkeys.
Signs and Disease: These lice feed on feathers and underlying skin over most parts of their host's main body. They cause irritation, pruritus, restlessness, repetitive grooming, debility, and reduced productivity.

[Continued]

Lipeurus (Philopteridae, Chewing lice)

[to Contents]

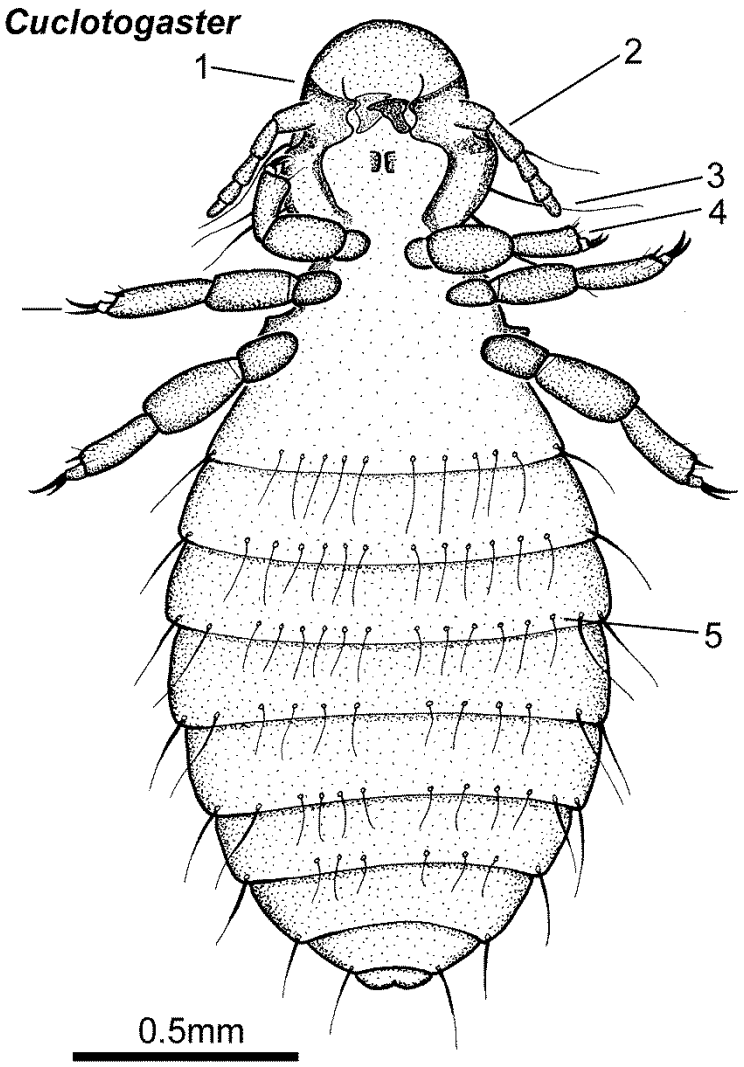


Characters: male, ventral. 1- Elongated shape is distinctive. 2- Head bears a projection just anterior to the antenna. 3- Antenna consists of 5 segments; on males its first segment is unusually long. 4- All legs have 2 claws. 5- Hind legs are twice the length of mid- and fore-legs. 6- Setae on the abdomen are sparse. 7- Two groups of long setae occur on dorsal surface of the posterior thorax. Also: body is medium size grey.

Hosts: *Lipeurus caponis* (Wing-louse) infests the underside of wings and tail of chickens.

Signs and disease: Irritation, pruritus, restlessness and poor growth rate are caused.

Cuclotogaster (Philopteridae, Chewing lice) [to Contents]



Characters: female, ventral. 1- Head has a rounded shape, without any prominences. 2- Antenna consists of 5 segments. 3- From the posterior margin of the head project three long setae. 4- Fore-legs are shorter than mid- and hind-legs. 5- Abdominal segments each have a row of medium length setae. 6- All legs have a pair of claws. Also: body is medium sized and grey.

Hosts: *Cuclotogaster heterographus* (Head-louse) infests chickens on the skin and feathers of their head; sometimes extending onto the neck.[5]

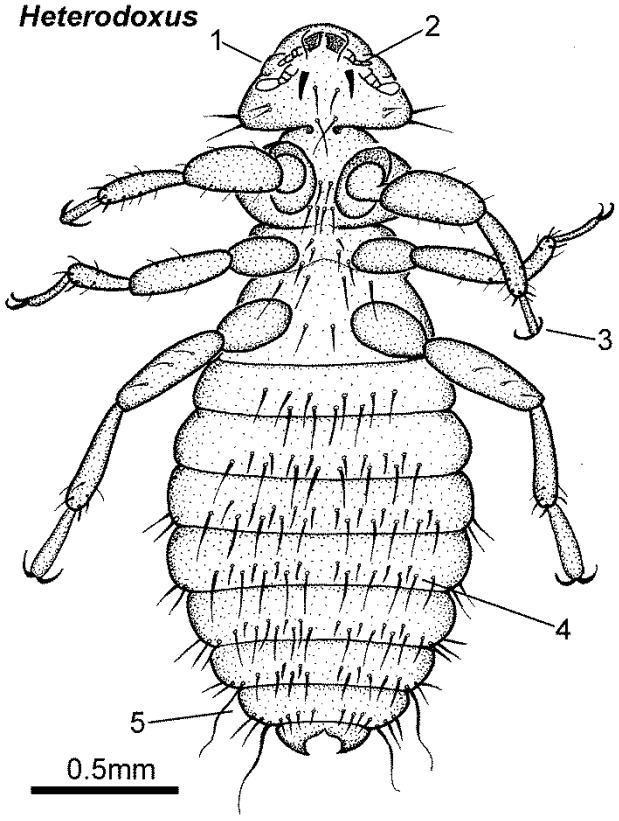
Signs and disease: Young birds are particularly harmed by these lice; infestations can build up rapidly, leaving the birds weak and even killing them.

Characters of Chewing lice of sub-order Amblycera

Lice in this group are similar in feeding habits to the ischnoceran lice because they feed with chewing mouthparts. Mouthparts are supplemented with a pair of palps next to the chewing mandibles. Antennae have 4 or 5 segments, but they are less visible than in the ischnoceran lice because they occupy an antennal groove in the head.

On the ventral surface of the head a pair of backward directed spines is usually visible. The thorax appears in two parts: the anterior segment, and the central plus posterior segments which are fused together. This division is clearest on the dorsal surface. Claws on the legs are variable, one or a pair depending on the genus. Amblyceran lice mostly parasitize birds, but also are found on marsupial mammals, and mammals in the Americas.

Heterodoxus (Boopidae, Chewing lice) [to Contents]



Characters: female, ventral. 1- Head is smoothly rounded anteriorly. 2- Palps are small, and anterior to the antennae. 3- All legs end in paired claws. 4- Abdominal segments have dense arrays of long setae. 5- Abdomen is broadly rounded at posterior. Also: body is large and yellow.

Hosts: *Heterodoxus spiniger* infests domestic dogs and other canids, also marsupial mammals. This species may need to be distinguished from *Trichodectes canis* on dogs in countries where both species of chewing lice

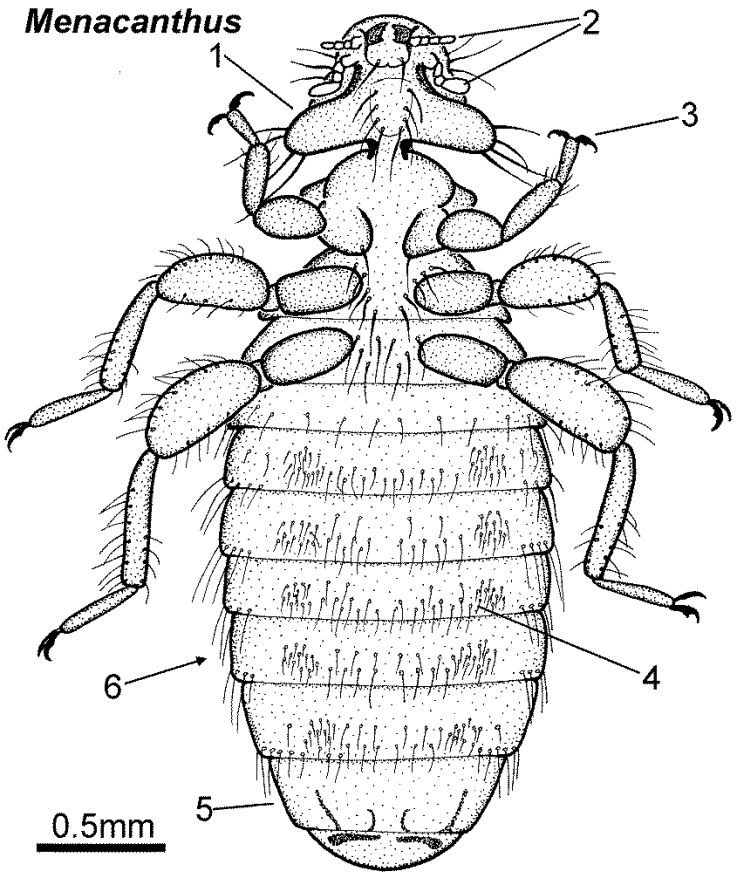
occur. *Heterodoxus spiniger* has also been reported infesting domestic cats but where the cats were close to heavily infested dogs.[6]

Disease: Pathological effects are only likely if the host is already in poor condition from other parasites or malnutrition. This louse is an intermediate host of the tapeworm of dogs, *Dipylidium caninum*.

Distribution: *Heterodoxus spiniger* is considered to have evolved in Australia. It has spread to tropical and sub-tropical regions of the Americas, and to Africa.

Menacanthus (Menoponidae, Chewing lice)

[to Contents]



Characters: female, ventral. 1- Head is distinctly narrow anteriorly but it bulges widely at the posterior. 2- Palps and antennae are conspicuous because of narrow shape of head anteriorly. 3- All legs end in paired claws. 4- Abdomen segments have a dense array of medium length setae. 5- Abdomen is broadly rounded at the posterior. 6- Spiracles are visible at dorsal edge of abdominal segments. Also: body is large and yellow.

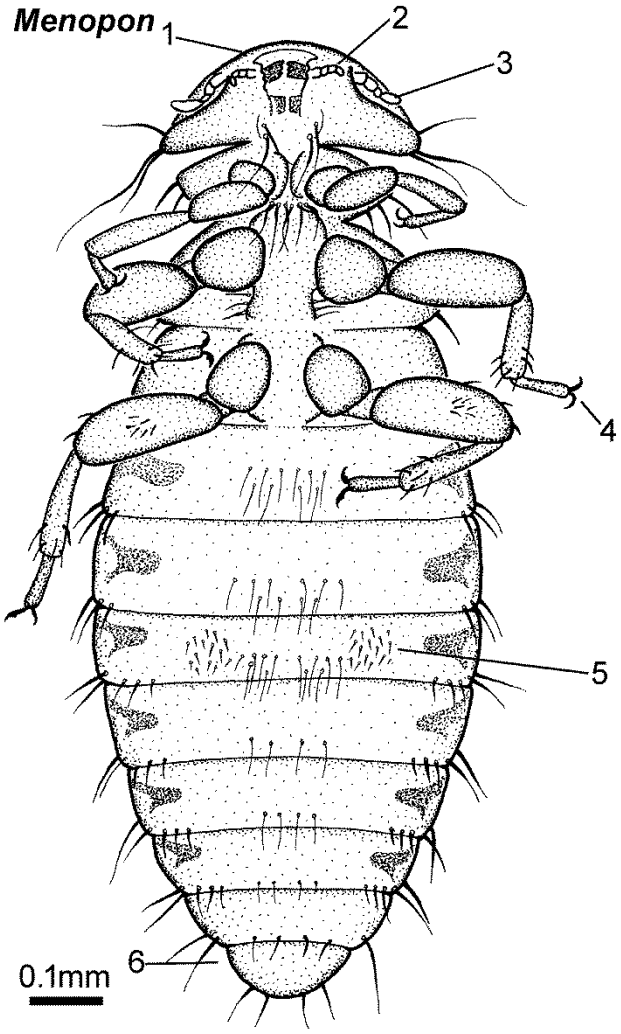
Hosts: *Menacanthus stramineus* (Chicken body-louse) infests chickens, other poultry species, aviary and game birds. Infestations are particularly dense on the breast, thighs, and around the vent.

Signs and disease: Irritation, pruritus, and restlessness cause loss of production. Infestations with the actively mobile *M. stramineus* can spread

rapidly through a flock, and also accumulate to dense levels on individual birds. The lice may penetrate the blood vessels at base of feathers, leading to anemia. This combination of pathological effects often greatly reduces productivity of a flock. This species is the most damaging of the bird lice.[7]

Menopon (Menoponidae, Chewing lice)

[to Contents]



Characters: female, ventral. 1- Head is widely and smoothly rounded at its anterior profile. 2- Palps are small, and aligned with the bases of the antennae. 3- Antennae lie within antennal grooves. 4- All legs end in a pair of claws. 5- Abdominal segments have sparse arrays of short and medium setae. 6- Abdomen is fairly narrow at the posterior. Also: body is very small and pale yellow.

Hosts: *Menopon gallinae* (Shaft-louse) infests chickens, turkeys and ducks on their breast and thigh feathers. It feeds only on the feathers and these lice can be seen in rows clasping a feather shaft.[8]

Disease: Heavy infestations in young birds may be highly damaging but this louse is rarely a severe pest to adult birds.

References

1. Heath, A.C.G., et al. (1995) Evidence for the role of the sheep biting-louse *Bovicola ovis* in producing cockle, a sheep pelt defect. Veterinary Parasitology, 59: 53-58. doi:10.1016/0304-4017(94)00723-P.
2. Rataj, A.V., et al. (2004) Ectoparasites: *Otodectes cynotis*, *Felicola subrostrata* and *Notoedres cati* in the ear of cats. Slovenian Veterinary Research, 4: 89-92.
3. Boreham, R.E. & Boreham, P.F.L. (1990) *Dipylidium caninum*: life cycle, epizootiology, and control. Compendium on Continuing Education for the Practicing Veterinarian, 12: 12-20.
4. Trivedi, M.C. et al. (1991) The distribution of lice (Phthiraptera) on poultry (*Gallus domesticus*). International Journal for Parasitology, 21: 247-249. doi:10.1016/0020-7519(91)90016-Z.
5. Fairchild, H.E. & Dahm, P.A. (1954) A taxonomic study of adult chicken lice found in the United States. Journal of the Kansas Entomological Society, 27: 106-111.
6. Agarwal, G.P., et al. (2009) Feeding habits of dog louse *Heterodoxus spiniger* (Mallophaga, Amblycera). Journal of Applied Entomology, 94: 134-137. doi:10.1111/k.1439-0418.1982.tb02557.x
7. DeVaney, J.A. (1975) Effects of the Chicken Body Louse *Menacanthus stramineus* on Caged Layers. Poutry Science, 55: 430-435.
8. Emerson, K.C. (1956) Mallophaga (Chewing Lice) Occurring on the Domestic Chicken. Journal of the Kansas Entomological Society, 29: 63-76.

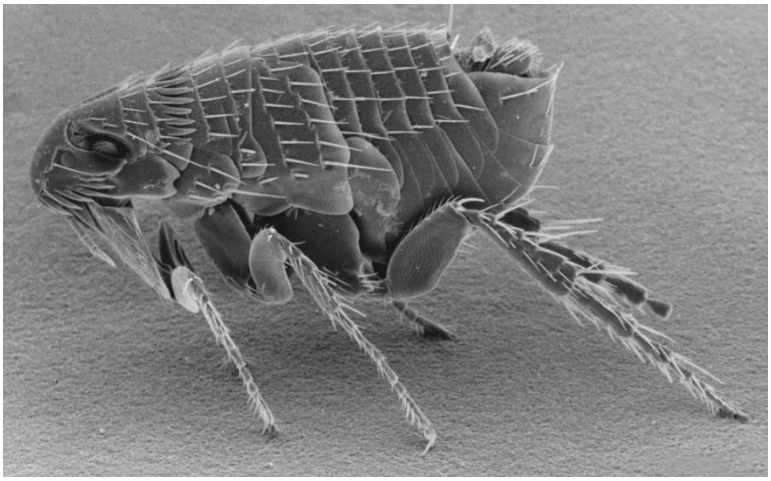
Fleas (Siphonaptera)

Characters of fleas

[to Contents]

All fleas are insects specialized as ectoparasites that feed on blood through piercing mouthparts. The adults are obligate parasites. Most species infest terrestrial mammals and often any one species of flea will readily infest several species of mammal. Fleas specialize to feed on hosts that are strongly associated with a nest, den, or other regular resting site. Some groups of fleas have adapted to feed on birds. In contrast to lice and acarines, only adult fleas are parasitic, and with some species of flea the adult can spend much time off the host between feeds.

[to Contents]



Scanning electron-micrograph shows an adult *Ctenocephalides* flea that commonly infests cats, dogs, other domestic animals, and humans.

The life-cycle has a complete metamorphosis. The illustration below for *Ctenocephalides* shows a fully grown larva, and the pupa which metamorphoses into the adult. Larval fleas feed on organic debris, and pellets of dried blood excreted by the adults. These pellets drop into the nest or resting site of the host. Adult fleas are typically ectoparasitic blood-feeders, but at least one species penetrates into the skin of its hosts.The larvae pupate at these sites, and pupae hatch rapidly as hungry adults when the host returns to nest. This nest-inhabiting behavior is called nidicolous.

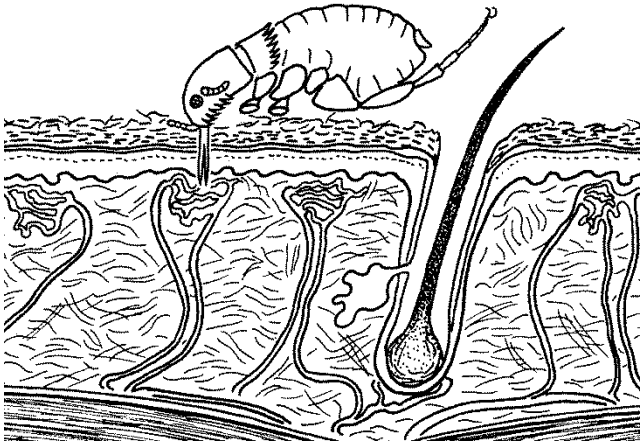


Diagram of feeding at skin shows an adult flea sucking blood from dermal capillaries of its host (for clarity only hind-legs are drawn).

Adult fleas are laterally flattened, never develop wings, the head bears a pair of compact antennae and a pair of eyes. On their hosts fleas have a shiny brown appearance. The thorax bears three pairs of strong legs, enabling the flea to jump from nest onto host. Fleas have many strong setae which hold

[to Contents]

them against the effects of host grooming. Of diagnostic use are the distinct rows of spines. The whole row is like a comb, technically called a ctenidium. These occur on the head (genal ctenidium) and on the first thoracic segment (pronotal ctenidium).[1,2,3]

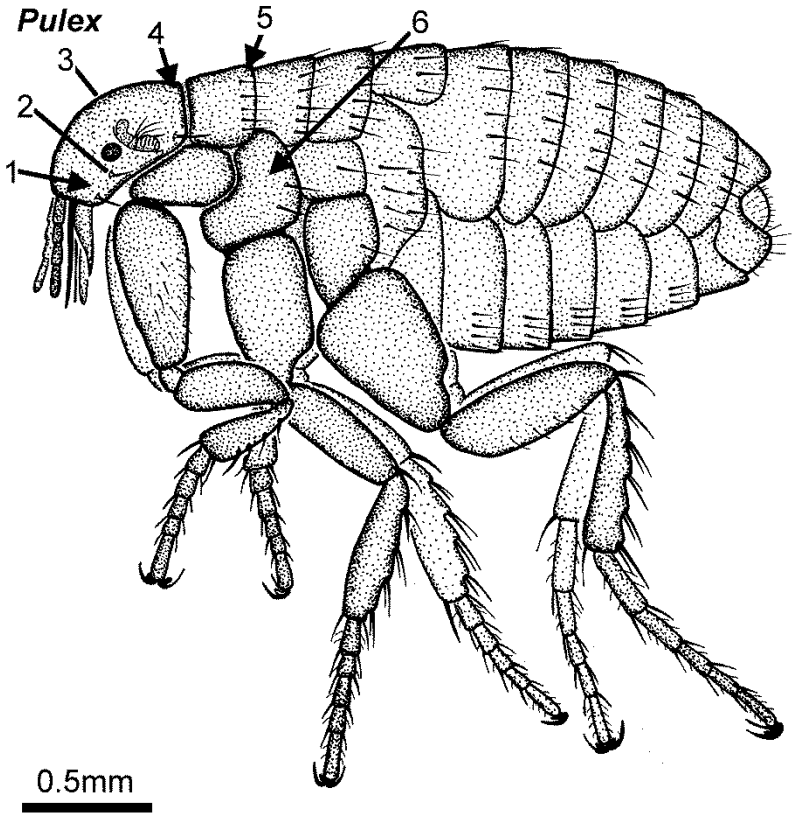
Glossary

- Complete metamorphosis = Process of developing from stage to stage of an invertebrate animal that involves a total change of form between immature stages and the reproductive adult stage (see diagram for two winged fly in Insects: General Characters).
- Ctenidium = a dense row of bristles, like a comb; occurs on head (genal ctenidium) or on thorax (pronotal ctenidium) (1 and 3 on *Ctenocephalides*).
- Pupa = The stage during which the change of form in a complete metamorphosis occurs (7 on *Ctenocephalides*).
- Meral rod = A vertical thickening of the body wall (mesopleuron part) of the thorax of fleas (4 on *Ctenocephalides*).
- Nidicolous = In this context this means the the behaviour of insects or acarines that inhabit the nests of their hosts.
- Ocular bristle = A small bristle or seta in front of the eye (2 on *Xenopsylla*).

[Continued]

Pulex (Pulicidae, Fleas)

[to Contents]



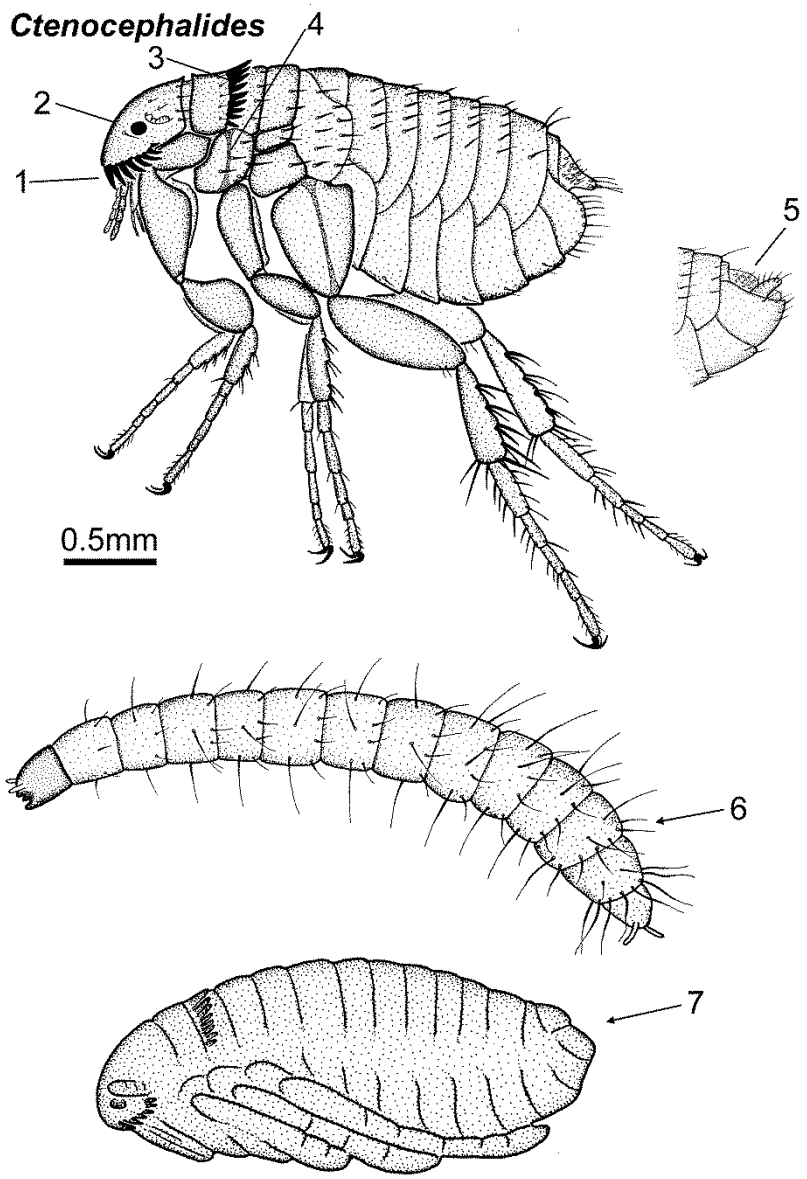
Characters: adult, lateral. 1- Genal ctenidium is absent. 2- Ocular bristle occurs below the eye. 3- Dorsal profile of head is smoothly rounded. 4- Bristles are absent from posterior margin of head. 5- Pronotal ctenidium is absent. 6- Meral rod is absent.

Hosts: Humans, pigs, dog, cats, rats and other mammals are liable to infestation with *Pulex irritans*.

Symptoms and disease: Irritation and biting stress are caused by heavy infestations, but for many humans infestation with *Ctenocephalides* cat or dog fleas is more likely. *Pulex irritans* can under some circumstances transmit the causative organism of bubonic plague, the bacterium *Yersinia pestis*.[4] However *P. irritans* does not readily feed on rats, and *Xenopsylla* species of flea are more important as vectors of this bacterium from its rat natural host to humans (see *Xenopsylla* below). Also there are various contaminative and contagious routes of transmission of *Yersinia pestis*.

Ctenocephalides (Pulicidae, Fleas)

[to Contents]



Characters: adult, larva, pupa. 1- Genal ctenidium has 10 or more spines (counting both sides). 2- Dorsal profile of head is smoothly rounded. 3- Pronotal ctenidium is present, usually with 16 spines (total of both sides). 4- Meral rod is present (a vertical thickening of exoskeleton on the mid thoracic segment). 5- Male posterior segments of abdomen. Also: 6- Larva. 7- Pupa.

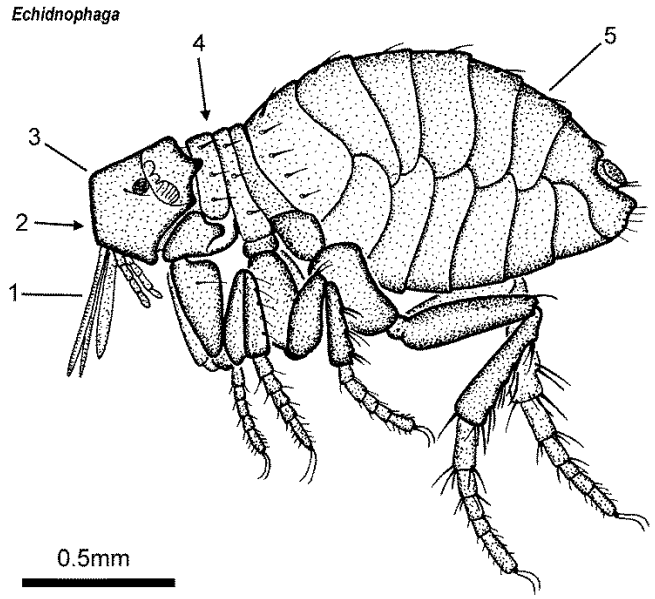
Hosts: *Ctenocephalides felis* (Cat-flea) infests domestic cats and dogs. The Cat-flea is often the commonest flea infesting dogs in human domestic environments. Also in tropical and sub-tropical regions Cat-fleas infest housed cattle, buffalo, sheep and goats. *Ctenocephalides canis* (Dog-flea) is mainly restricted to dogs. Both these flea species will readily feed on humans but domestic animal hosts sustain the populations of these fleas.[5]
Signs and symptoms: Infestation leads to irritation, pruritus, anemia and frequent grooming. The quality of the host's hair-coat declines. The blood

excreted by adult fleas (for the benefit of the larvae in the host's nest or bedding) can be detected as dry pellets that will turn red if combed out onto a damp towel or paper.

Disease: Heavy infestations of cats and dogs cause considerable biting-stress and often lead to flea-bite hypersensitivity. Massive infestations of goats when confined at night in the same enclosures have been reported as the direct cause of death of some goats.[6] These fleas act as intermediate hosts of the dog tapeworm, *Dipylidium caninum*.[7]

Echidnophaga (Pulicidae, Fleas)

[to Contents]



Characters: adult, lateral. 1- Mouthparts are long and project conspicuously from the head. 2- Genal ctenidium is absent. 3- Dorsal profile of head is distinctly angular, forming a pentagonal shape. 4-Pronotal ctenidium is absent. 5- Abdomen is short.

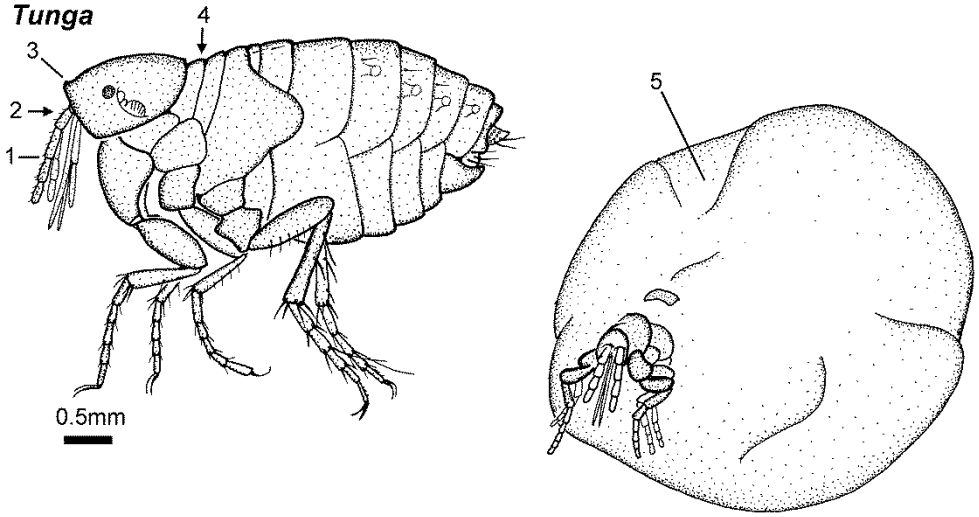
Hosts: *Echidnophaga gallinacae* (Sticktight-flea) is predominantly a parasite of poultry and other birds but it will feed opportunistically on mammals.

Signs and disease: The Sticktight-flea is conspicuous because adults remain at the same place on the skin of their host between feeds. The favored feeding site is on the head, also on areas of bare skin; large groups of adults cluster together. In moderate to heavy infestations this type of feeding causes severe biting-stress, can damage the head of the bird and greatly reduce productivity of the birds.[8]

Distribution: Most common in tropical and sub-tropical regions.

Tunga (Pulicidae, Fleas)

[to Contents]



Characters: female, lateral. 1- Mouthparts are long and project conspicuously from the head. 2- Genal ctenidium is absent. 3- Dorsal profile of head is angular, forming a triangular shape. 4- Pronotal ctenidium is absent. 5- Abdomen of feeding female expands greatly.

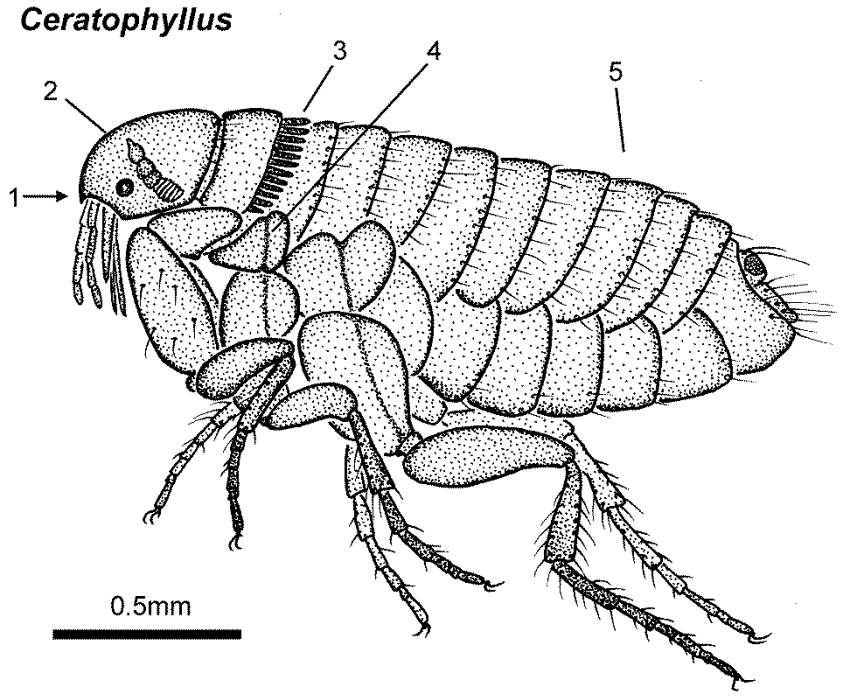
Hosts: *Tunga penetrans* (Jiggers, Chigger-flea, Chigoe-flea, Sand-flea, but avoid confusion with names of trombiculid mites) infests pigs, and many other species of mammals. Dogs are often badly affected. Humans are readily infested when they walk with bare feet exposed.[9]

Signs, symptoms and disease: An unfed female rapidly burrows head first deeply into skin of its host. There it continues to feed, expanding its abdomen enormously as it produces eggs. On humans a single infesting flea appears like a brown boil with a small opening to the exterior. Eggs are laid from the part of abdomen which protrudes slightly from the host's skin. In an early infestation this brown spot may be the only sign. A single infesting flea causes pruritus followed by pain. Infestations can accumulate, and the site of inflammatory reactions to the fleas can become bacterially infected. When accidentally transported from South America to Africa these fleas have caused great problems to people and their domestic animals living in Africa.

Distribution: *Tunga penetrans* is a parasite of tropical and sub-tropical regions.

Ceratophyllus (Ceratophyllidae, Fleas)

[to Contents]



Characters: female, lateral. 1- Genal ctenidium is absent. 2- Dorsal profile of head is smoothly rounded. 3- Pronotal ctenidium has 24 spines (total of both sides). 4- Meral rod is present. 5- Abdomen is elongated.

Hosts: *Ceratophyllus gallinae* (European chicken-flea) commonly infests poultry and other birds and will also opportunistically feed on domestic cats and dogs, and on humans.[10]

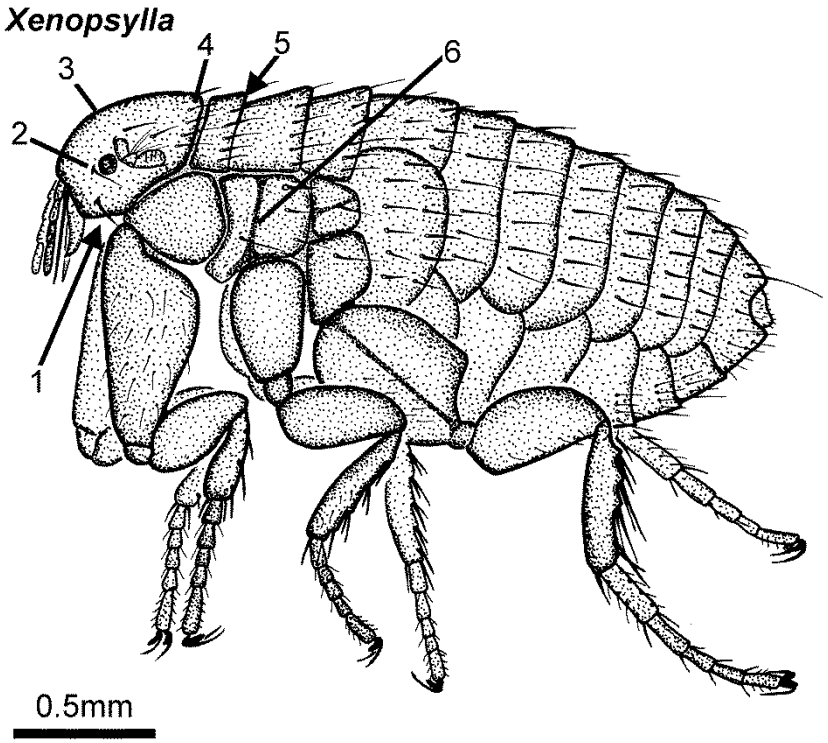
Signs and disease: Irritation, restlessness, and allergic dermatitis are caused; also anemia results from in heavy infestations.

Distribution: *Ceratophyllus gallinae* occurs in Europe and some regions of Asia, but has also spread to some parts of North America. *Ceratophyllus niger* occurs in Canada and USA.

[Continued]

Xenopsylla (Pulicidae, Fleas)

[to Contents]



Characters: adult, lateral. 1-Genal ctenidium is absent. 2- Ocular bristle is present below the eye. 3- Dorsal profile of head is smoothly rounded. 4- Bristles occur as a row on posterior margin of head. 5- Pronotal ctenidium is absent. 6- Meral rod is present.

Hosts: Rats principally, but these fleas will also readily feed on humans if its natural host dies and humans are available as alternative hosts in domestic housing.

Disease: The Oriental Rat-flea, *Xenopsylla cheopis* is the main transmitter of the bacterium *Yersinia pestis,* which causes bubonic plague in humans. This flea species also transmits to humans *Rickettsia typhi*, the causative bacterium of murine or endemic typhus (contrast with epidemic typhus in relation to *Pediculus* lice).[11]

References

1. Haeselbarth, E., et al. (1996) *The Arthropod Parasites of Vertebrates in Africa south of the Sahara*. Vol. III (Insecta, excluding Phthiraptera). Johannesburg, South African Institute for Medical Research.
2. Quinn, P.J., et al. (1997) *Microbial and Parasitic Diseases of the Dog and Cat*. London, W.B.Saunders Co. Ltd. ISBN 0-7020-1985-2.
3. Rothschild M. & Clay T. (1957) *Fleas, Flukes and Cuckoos: a Study of Bird Parasites*. London, Collins.
4. Ratovonjato, J.M., et al. (2014) *Yersinia pestis* in *Pulex irritans* fleas during plague outbreak, Madagascar. Emerging Infectious Diseases, 20: 1414-1415. doi: 10.3201/eid2008.130629.

5. Dryden, M.W. (1989) Host association, on-host longevity and egg production of *Ctenocephalides felis felis*. Veterinary Parasitology, 34: 117-122. doi: 10.1016/0304-4017(89)90171-4.
6. Fagbemi, B. O. (1982). Effect of *Ctenocephalides felis strongylus* infestation on the performance of West African dwarf sheep and goats. Veterinary Quarterly, 4: 92-95.
7. Guzman, R.F. (1984) A survey of cats and dogs for fleas: with particular reference to their role as intermediate hosts of *Dipylidium caninum*. New Zealand Veterinary Journal, 32: 71-73.
8. Parman, D.C. (1923) Biological notes on the Hen Flea, *Echidnophaga gallinacea*. Journal of Agricultural Research, 23: 1007-1009.
9. Eisele, M., et al. (2003) Investigations on the biology, epidemiology, pathology and control of *Tunga penetrans* in Brazil. 1. Natural history of tungiasis in man. Parasitology Research, 9: 87-99. doi: 10.1007/s00436-002- 0817-y.
10. Haag-Wackernagel, D. & Spiewak, R. (2004) Human infestation by pigeon fleas (*Ceratophyllus columbae*) from feral pigeons. Annals of Agricultural and Environmental Medicine, 11: 343-346.
11. Burroughs, A.L. (1947) Sylvatic plague studies. The vector efficiency of nine species of flea compared with *Xenopsylla cheopis*. Journal of Hygiene, 45: 371-396.

Mosquitoes, Midges, Sandflies and Blackflies (Diptera)

Characters of parasitic dipteran flies

[to Contents]

Dipteran flies are typical insects. Most species are free-living, but the parasitic species are of great medical and veterinary importance. The wings are one on each side of the middle segment of the thorax. The hind thoracic segment has a pair of modified wings called halteres. These are small knobs on a short stalk that assist flying. At the base of the wings are various extensions of the wing surface, called squamae.The adult body of dipteran flies is divided into an obvious head, thorax and abdomen. The head bears complex mouthparts, sensory palps to assist feeding, eyes and antennae to find hosts and mates. Some types of dipterans that are highly specialized for parasitism (the hippoboscids) either lose their wings when they find a host, or never develop wings. Dipteran flies all have a complete metamorphosis.

Most ectoparasitic dipterans feed on their hosts as adults; but an important group feed on their hosts as larvae. These flesh feeding larvae cause the disease myiasis. Of such myiasis flies the ones most highly adapted for parasitism have no mouthparts in the adult stage; all feeding in the life-cycle is done by the larvae.

Classification within the Diptera is complex. This book provides a simple grouping by sub-order and family names. The two sub-orders are

Nematocera and Brachycera. Note that the former sub-order Cyclorrhapha is now placed within the Brachycera (see articles on Diptera in Wikipedia).[1]

Nematoceran flies - characters of mosquitoes (Culicidae)

These flies are all typical nematocerans, with long antenna consisting of many similar segments. All mosquitoes are specialized for blood-sucking as adult females. The males feed on plant nectar. Larvae and nymphs inhabit stagnant water. Mouthparts form a long proboscis consisting of a labium as a protective sheath and within this sheath is a bundle of very fine elongated mouthparts that form a flexible piercing and sucking tube. The labium folds up when the piecing mouthparts are in use. Antennae are long. Antennae of females have short fine setae at each segment; male antennae have long fine seta at each segment, appearing like a brush. Legs are very long and thin and wings have small squamae, and small scales arranged above the wing-veins.

Photograph shows a live female *Anopheles* mosquito sucking blood from a person's skin; the labium is folded away from the piercing mouthparts which show as the narrow reddish tube. Note the feeding stance of this anopheline mosquito, with abdomen held up. (Photograph by James Gathany).

Mosquito genera of medical and veterinary importance are grouped into two taxonomic types: culicine (of many genera, *Culex* is typical), and anopheline (mainly the genus *Anopheles*). The adults of these two groups have typical resting stances. Larvae and pupae are aquatic and of the two groups have different shape and behavior when suspended below the water surface to breathe. Mosquitoes populations can seasonally, or in permanently favorable larval habitats, build up to dense populations. These cause biting-stress to domestic animals and humans that is severe to intolerable, making wide areas of land uninhabitable.

[to Contents]

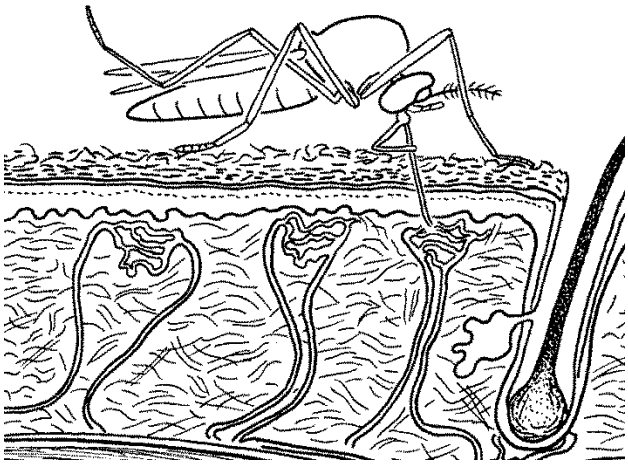


Diagram of feeding at skin represents a mosquito piercing dermal capillaries of its host using very fine flexible mouthparts (relative scales not accurate).

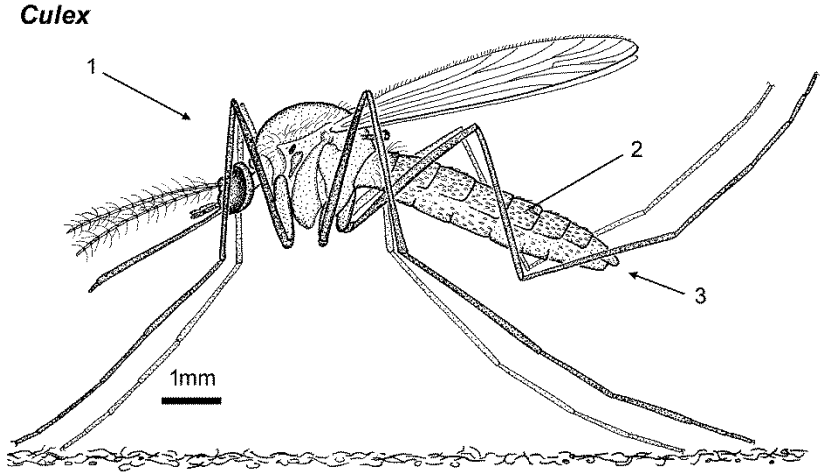
Mosquitoes are biological vectors of numerous pathogenic viruses, bacteria, protozoa, and worms between domestic animals and humans. Here only the most prominent pathogens and diseases are emphasized. There are many genera of mosquitoes of potential medical and veterinary importance but their identification is work for a specialist. Only six representative genera are shown here. Studies of the taxonomy and biology of mosquitoes have revealed extremely complex and varied adaptations, often making very difficult the differentiation of species of significant medical and veterinary importance using the traditional morphological criteria.[2,3,4,5]

Glossary

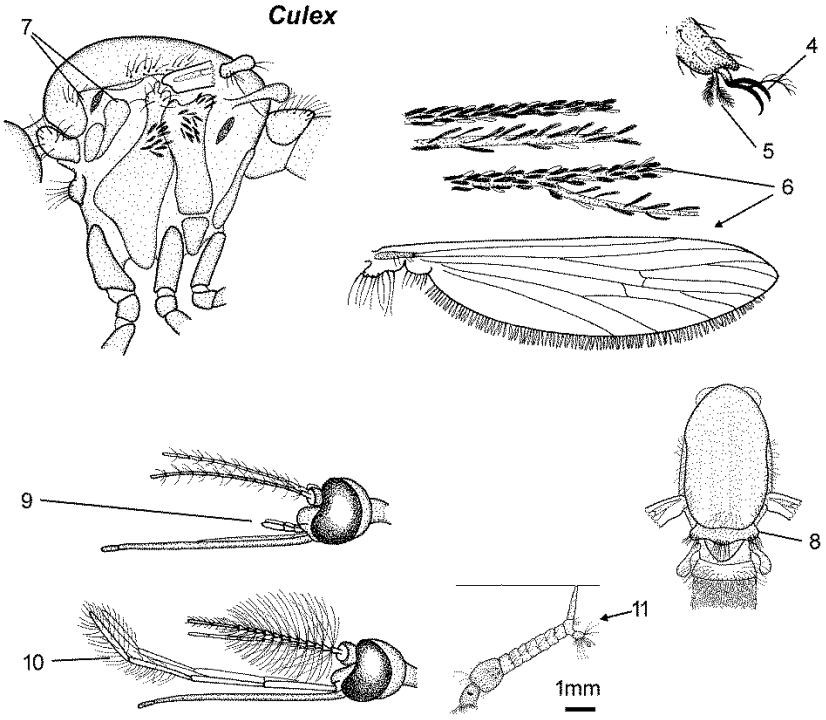
- Halter = A paired organ in the Diptera, a knob on a short stalk below and behind the forewings (see *Culicoides* photograph and drawing).
- Humeral pit = A paired depression on the anterior and dorsal surface of the thorax of biting midges (2 on *Culicoides*).
- Labium = A component of the mouthparts of insects that in nematoceran flies acts as a sheath for the piercing elements.
- Myiasis = Infestation of animals with larvae of dipteran flies (see Blowflies).
- Palps = Paired sensory organs associated with the mouthparts of invertebrate animals; with mosquitoes their length relative to the antennae are important for identification (9, 10 on *Culex*).
- Pre- and post-spiracular setae = Small groups of setae on either side of the anterior spiracle on the thorax (see 2 on *Psorophora*).
- Pulvillus = An adhesive pad or hairs at end of legs (5 on *Culex*)
- Scutellum = A ridge on the posterior segment of thorax of mosquitoes (8 on *Culex*).
- Squamae = Flaps as extensions of the wing surface close to the insertion point on thorax (6 on *Culex*).
- Radial cell = Part of the wing of midges tightly enclosed by conspicuous veins at the leading edge of wing (3 on *Leptoconops*).
- Vein = Fine tubes that support the wings of insects, they inflate to expand the wings after emergence from the pupal stage (6 on *Culex*)

Culex (Culicidae, Culicine Mosquitoes)

[to Contents]



Characters: female, lateral. 1- Female in resting stance typical of culicine mosquitoes: body forms an arch with abdomen pointing downwards. 2- Scales on abdomen form a dense covering without a distinct colored pattern. 3- Abdomen is blunt ended.



Characters: thorax and other parts. 4- Claws on fore-legs of females are simple (claws on males are toothed). 5- Large pulvilli are present next to claws of females. 6- Scales on wing are narrow; they are without a metallic coloration; wings have small squamae at their base. 7- Setae are absent from the prespiracular area and the postspiracular area. (These areas surround the anterior spiracle of the thorax, shown as the dark ovals.) 8- The scutellum has 3 distinct lobes on its posterior margin; each lobe bears a tuft of setae. 9- Female head has short palps. 10- Male head has long palps, and

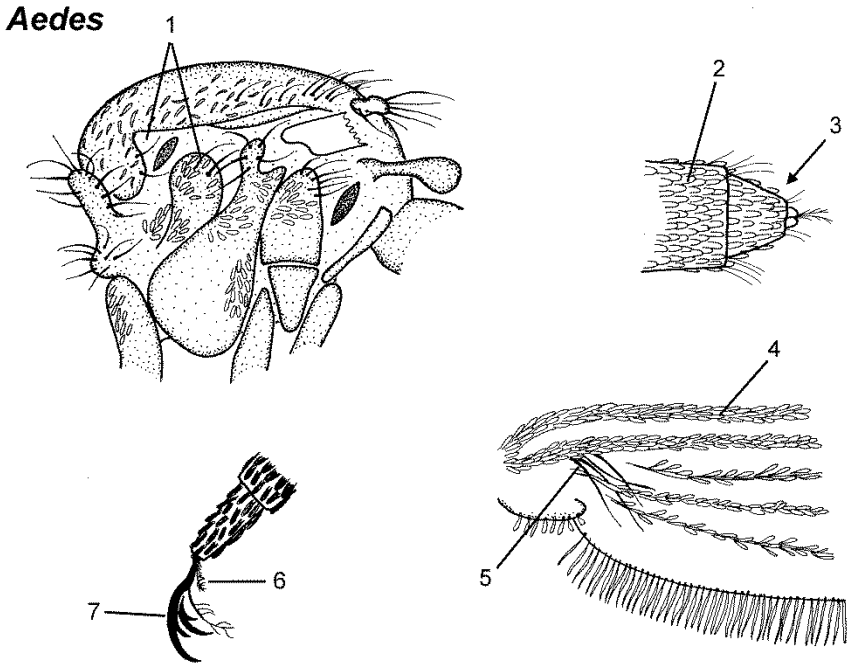
bushy antennae. 11- Larva in breathing position, suspended down from surface of water.

Hosts: Cattle, sheep, horses, birds, reptiles, and humans are infested. Different species have feeding preferences for different groups of hosts, and sometimes these preferences are specific. These flies feed mainly at night-time.

Signs and disease: Irritation and avoidance behavior and dermal hypersensitivity are caused. Biting-stress varies from slight with low numbers feeding through to intolerable with the massive numbers that can occur. Various *Culex* species transmit West Nile virus between birds and horses, the nematode worm *Dirofilaria immitis* that causes heartworm to dogs, and several species of *Setaria* filarial nematodes. Some *Culex* species transmit *Plasmodium* protozoa that cause malaria in birds. (Note that transmission of protozoa causing various forms of malaria is not restricted to *Anopheles* species of mosquito. It is only the *Plasmodium* species of protozoa causing malaria in humans that are restricted to transmission by *Anopheles* mosquitoes.) Species of *Culex* transmit the nematode worm *Wuchereria bancrofti*, the cause of lymphatic filariasis in humans (which may lead to elephantiasis).[6]

Aedes (Culicidae, Culicine Mosquitoes)

[to Contents]

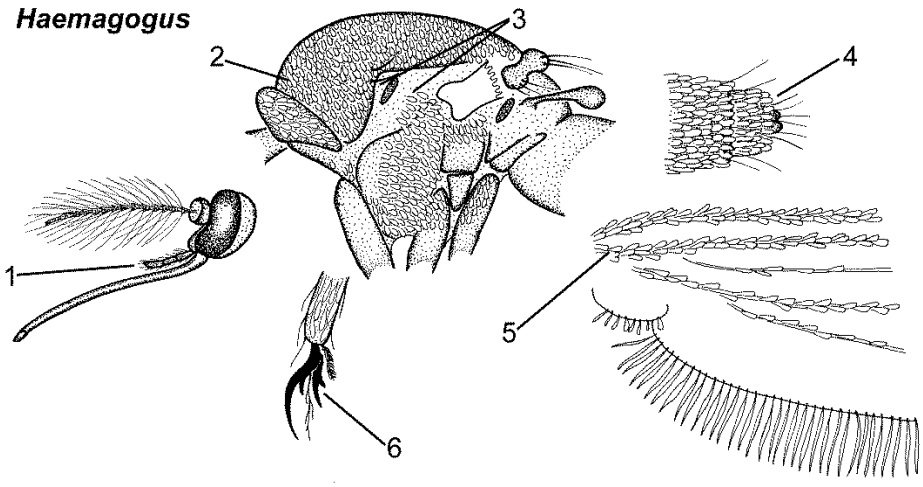


Characters: thorax and other parts. 1- Setae are absent from the prespiracular area but are present in the postspiracular area. 2- Scales on the abdomen give a dense covering: they may form silver colored patterns. 3- Abdomen is usually sharp ended. 4- Scales on wing are narrow. 5- Stem-vein of the wings has at its base a group of long thick setae on the ventral surface. 6- Pulvilli on females are small or

like fine setae. 7- Claws on the fore-legs of females and males are toothed.

Hosts: Cattle, sheep, horses, birds, reptiles, and humans. Different species have feeding preferences for different groups of hosts, and sometimes these preferences are specific. These flies feed at night-time.
Signs and disease: Irritation and avoidance behavior and dermal hypersensitivity are caused. Biting-stress varies from slight with low numbers feeding, through to intense with the massive numbers that can occur. Species of *Aedes* are biological vectors of Equine encephalitis virus, the nematode *Dirofilaria immitis* causing heartworm in dogs, and species of *Plasmodium* to birds causing avian malaria. *Aedes aegypti* is the principal vector of the viruses causing Yellow- fever, and Dengue-fever, in humans; it also transmits Zika virus. Species of *Aedes* transmit the nematode worm *Wuchereria bancrofti*, the cause of lymphatic filariasis in humans (which may lead to elephantiasis).[7]
Distribution: Typically *Aedes* species occur in the tropics and sub-tropics but some species have spread more temperate regions on shipping transports.

Haemagogus (Culicidae, Culicine mosquitoes) [to Contents]

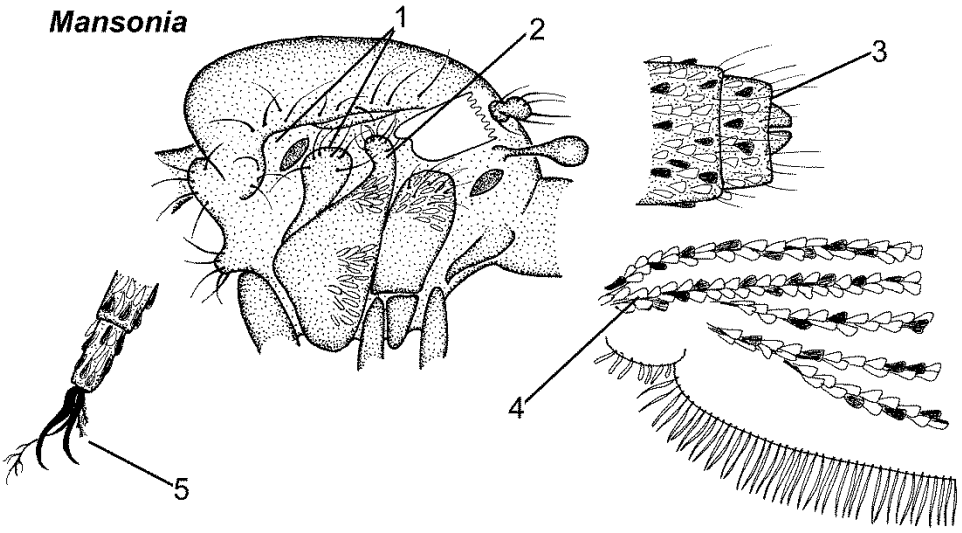


Characters: thorax and other parts. 1- Palps of males are smaller than proboscis. 2- Thorax and abdomen are widely covered with scales of metallic colors. 3- Thorax is without prespiracular or postspiracular setae. 4- Abdomen has a blunt end. 5- Scales on wing veins are narrow. 6- Females and males have fore-legs with toothed claws.

Hosts, disease and distribution: These mosquitoes feed on monkeys and also humans. They transmit the virus of Yellow Fever. They occur in tropical and sub-tropical areas of North and South America.

Mansonia (Culicidae, Culicine Mosquitoes)

[to Contents]

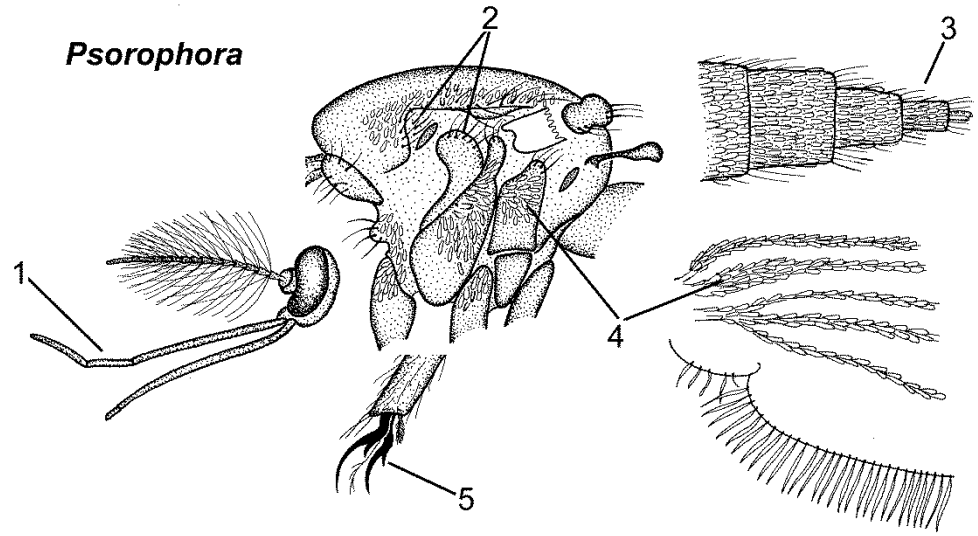


Characters: thorax and other parts. 1- Thorax is without prespiracular setae, but postspiracular setae are present. 2- Thorax has a sparse covering of long setae and broad scales. 3- Abdomen is blunt ended. 4- Wings have broad scales on their veins and these scales may form speckled patterns. 5- Claws of the legs are without spurs and the pulvilli are small or absent.

Hosts and disease: *Mansonia* is one of the genera of culicine mosquitoes with species that transmit *Wuchereria bancrofti* and *Brugia* species of nematode worms to humans, causative agents of lymphatic filariasis in humans (which can lead to elephantiasis).[8]

[Continued]

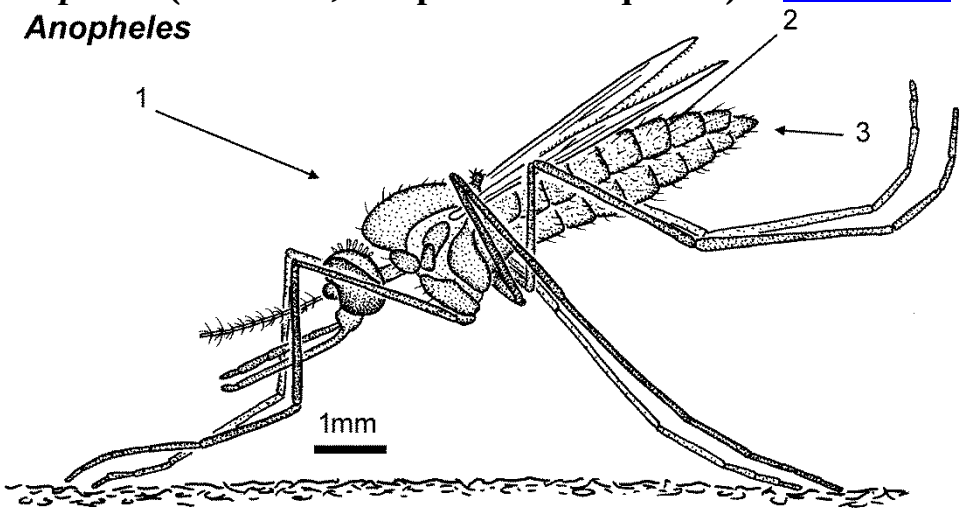
Psorophora (Culicidae, Culicine Mosquitoes) [to Contents]



Characters: thorax and other parts. 1- Palps of male are longer than proboscis. 2- Prespiracular and postspiracular setae are present. 3- Abdomen has a pointed end. 4- Scales on body and veins of wings are narrow. 5- Females and males have fore-legs with toothed claws.

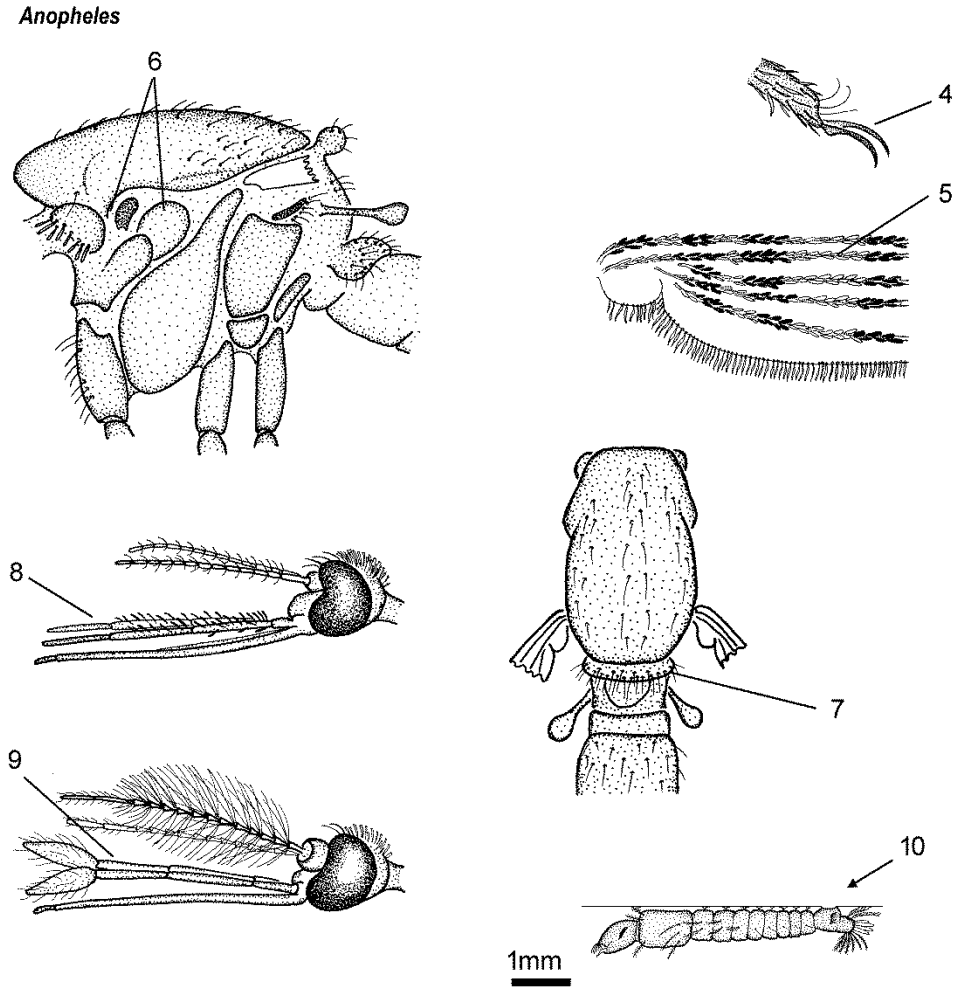
Hosts and disease: Horses are one of the hosts of this genus of mosquitoes. *Psorophora ferox* is one of the species that transmits to horses the virus causing Venezuelan equine encephalitis.

Anopheles (Culicidae, Anopheline Mosquitoes) [to Contents]



Characters: female, lateral. 1- Female in resting stance that is typical of *Anopheles*, whole body forms a straight line with abdomen held higher than head. 2- Scales on the abdomen are absent. 3- Abdomen is blunt or sharp ended, depending on the species.

[Continued]



Characters: thorax and other parts. 4- Claws on the legs of females and males are simple. Pulvilli are absent. 5- Scales on wing are narrow and vary in color to form distinct patterns. 6- Setae are absent from the prespiracular area and the postspiracular area. 7- The scutellum has a posterior margin with a slightly wavy or evenly rounded margin and setae are distributed evenly around this margin. 8- Female head has long palps. 9- Male head has long palps with club shaped outermost segment; antennae are bushy. 10- Larva in typical breathing position, suspended parallel to the surface of water.

Hosts: Cattle, sheep, horses, birds, reptiles, and humans are used as hosts. These flies feed at night-time.

Signs and disease: These mosquitoes cause irritation and avoidance behavior, also dermal hypersensitivity. Biting-stress varies from slight with low numbers feeding through to intense with the massive numbers that can occur. Various species of *Anopheles* are biological vectors of the viruses causing the various forms of equine encephalitis. They also transmit the nematode *Dirofilaria immitis* causing heartworm in dogs. Species of *Anopheles* transmit the nematode worm *Wuchereria bancrofti*, the cause of lymphatic filariasis in humans (which may lead to elephantiasis). The *Anopheles gambiae* complex of species is an example of various anopheline

mosquito species that are adapted to feeding on humans and are the principal biological vectors of those species of *Plasmodium* protozoa that cause human malaria.[9,10] (Other genera of mosquitoes may transmit protozoa causing forms of malaria in domestic and wild animals.)
Distribution: This is mainly tropical and sub-tropical, but some anopheline species inhabit cool temperate regions.

Characters of blood-sucking midges (Ceratopogonidae)

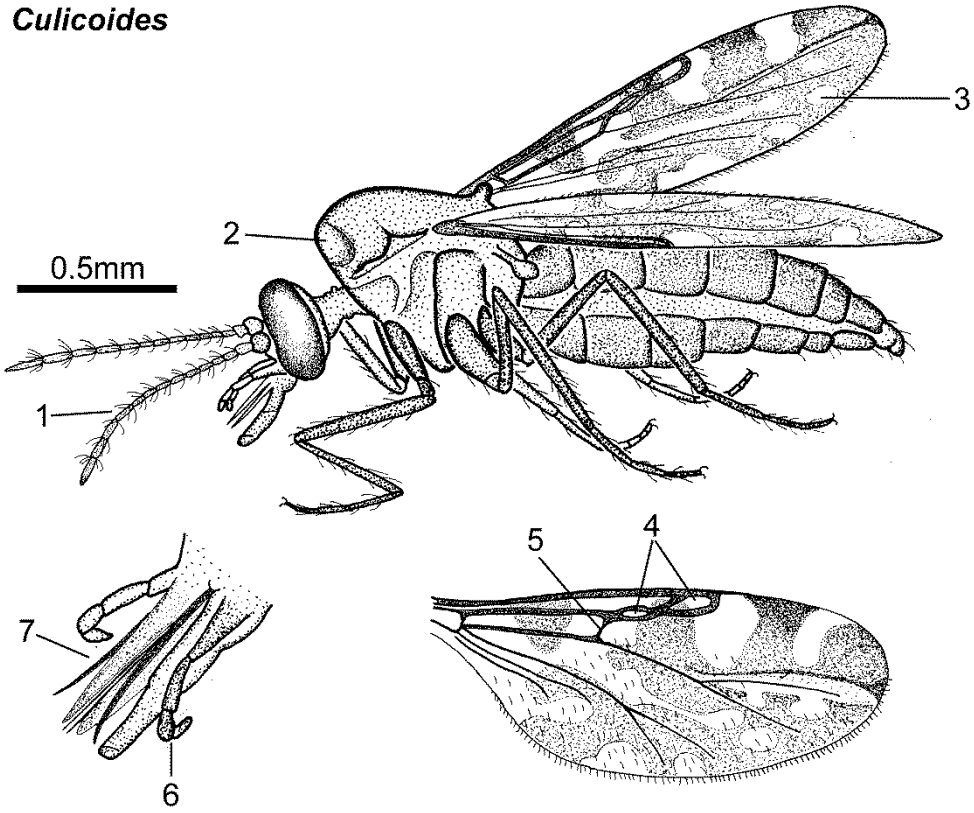
These flies are all typical nematoceran flies, with long antennae consisting of many similar segments. Female midges feed on blood using complex mouthparts with pairs of cutting blades that make a wound down to the capillary blood. Their mouthparts are similar to the much larger tabanid Horse-flies, which is why their feeding is so irritating. Larvae and nymphs inhabit wet soil and bogs.

Photograph shows a female *Culicoides* biting midge, with its prominent piercing mouthparts and conspicuously patterned wings. A halter protrudes from the posterior profile of the thorax. Lateral view of specimen mounted on a microscope slide.

Wings of blood-sucking midges have a reduced number of veins compared to mosquitoes and there are one or two distinct cells within the pattern of veins at center of the leading edge. These midges are all small, and often called names that reflect that: No-see-ums, Punkies, and so on. However, they are also sometimes called Sand-flies, but to entomologists this name means flies in the family Psychodidae. The genera *Culicoides* and *Leptoconops* are the most important to health. *Forcipomyia* species are also of minor importance.[11]

Culicoides (Ceratopogonidae, Midges)

[to Contents]

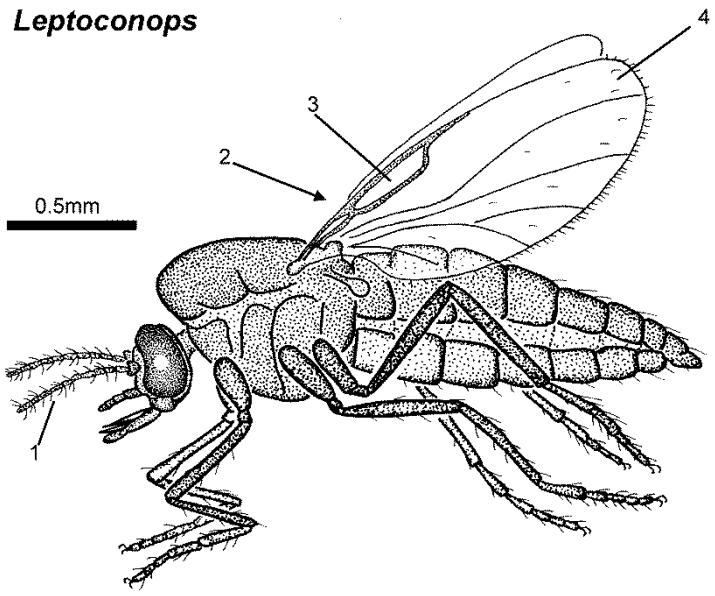


Characters: female, lateral. 1- Antennae of females have 14 or 15 segments. 2- Thorax has a pair of indentations called humeral pits. 3- Wings usually have distinctive patterns of dark grey/brown areas and clear areas. 4- Two radial cells are present. 5- Between the radial vein and the m vein, the r-m cross vein is present. 6- Palps are short and simple. 7- Mouthparts of females have complex cutting and piercing elements.

Hosts: Cattle, sheep, horses, birds, and humans are used as hosts. Numerous species of *Culicoides* have a fairly narrow range of preferred hosts in tropical regions but some species in cool temperate climates will feed on a wide range of vertebrate animals, as available. These flies feed mainly at night-time.

Signs, symptoms and disease: Irritation, biting-stress and avoidance behavior are caused to both livestock and humans. Agricultural and forestry workers suffer reduced productivity. Dermal hypersensitivity develops after repeated exposure to feeding *Culicoides*. This causes much trouble to horses, and is known as Sweet-itch, Queensland-itch, and similar. Numbers of midges can build up to dense swarms around cattle and sheep, reducing their productivity through stress and reduced grazing.[12] *Culicoides imicola* is a biological vector of Bluetongue virus between sheep in Africa and Mediterranean countries, *C. variipennis* transmits this virus in North America. African horse sickness virus is transmitted between equids by *Culicoides* species in Africa and southern Europe, through to Pakistan.[13]

Leptoconops (Ceratopogonidae, Midges) [to Contents]



Characters: female, lateral. 1- Antennae have 12 to 14 segments. 2- Wings have no r-m cross vein. 3- Wings have a large second radial cell and often a smaller first radial cell. 4- Wings are semi-transparent white, without patterns, and contrasting with black body of midge.

Hosts: Cattle, sheep, horses, birds, and humans are the hosts – as for *Culicoides*.
Signs and disease: Irritation, biting-stress and dermal hypersensitivity are caused – as for *Culicoides*.
Distribution: Tropical and sub-tropical regions mainly are inhabited.

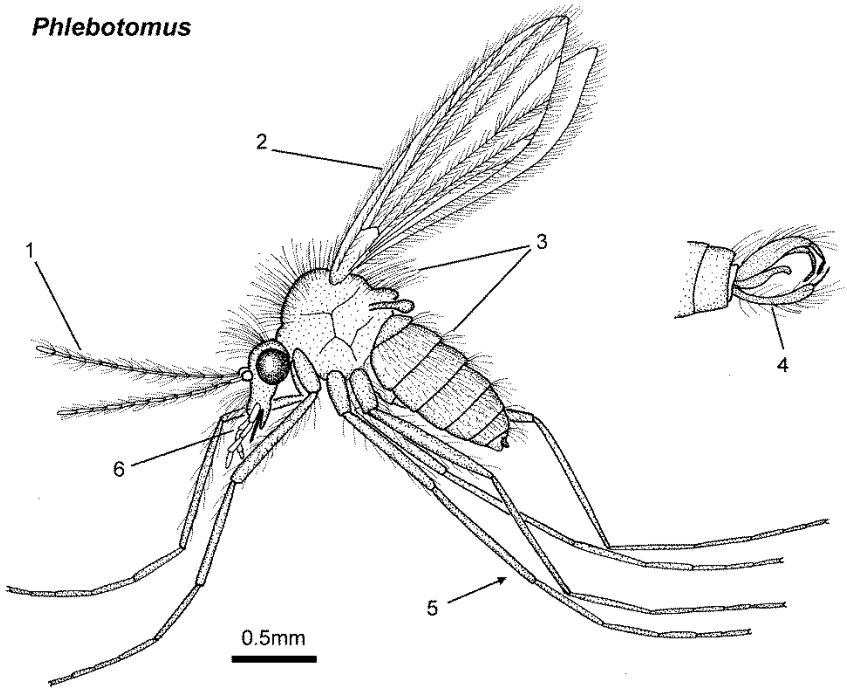
Characters of Sand-flies (Psychodidae)

These flies are all typical nematocerans, with long antennae consisting of many similar segments. Sand-flies are nearly as small as ceratopogonid midges, but structurally are more like mosquitoes, with complex veins in their wings and long thin legs.

The females feed on blood; larva and nymphs inhabit surface of soil. Sand-flies are most important because of their transmission of *Leishmania* species of protozoa, causing visceral and cutaneous Leishmaniasis in many tropical regions. Additionally, Leishmaniasis is a serious problem for domestic dogs where these flies are abundant. Species in the genera *Phlebotomus* and *Lutzomyia* are most important. These genera are closely similar and only *Phlebotomus* is shown here.

Phlebotomus (Psychodidae, Sand-flies)

[to Contents]



Characters: female, lateral. 1- Antennae are of typical nematoceran type: long, multi-segmented and covered in fine setae. 2- Wings are long, with a complex pattern of veins and covered in long thin setae. 3- Thorax and abdomen are thickly covered with long thin setae. 4- Males are characterized by their abdominal claspers. 5- Legs are slender and long. 6- Mouthparts consist of a short set of piercing parts and the associated sensory palps.

Hosts: Humans and many species of livestock animals, wild mammals, birds, and reptiles are used as hosts. These flies feed during night-time.
Signs and disease: These flies do not usually feed in large numbers or cause obvious irritation or biting-stress. *Phlebotomus* and *Lutzomyia* species are principally important as vectors of many *Leishmania* species of protozoa that cause cutaneous and visceral leishmaniasis.[14]
Distribution: Sand-flies inhabit tropical and sub-tropical regions: *Phlebotomus* in Africa and Asia, *Lutzomyia* in the Americas.

Characters of Blackflies and Buffalo-gnats (Simuliidae)

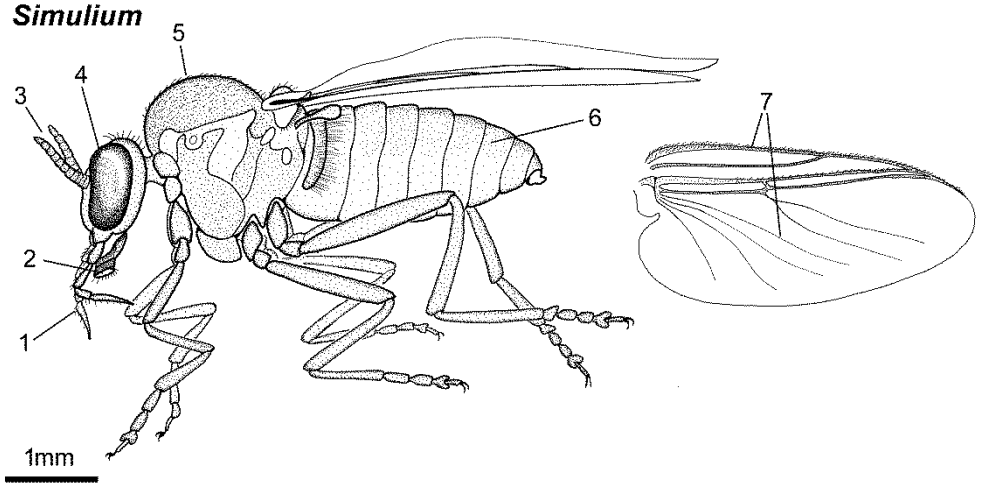
These flies are nematocerans, with relatively short antennae that consist of many similar and compact segments. These flies are small, compact, and dark colored; they are larger than *Culicoides* midges but smaller than *Haematobia* horn-flies.

Female Blackflies feed on blood. Larva and nymphs inhabit fast running clear rivers. Blackflies are notorious in association with River-blindness of humans. The importance of Blackflies to domestic animals is mainly by

causing severe to intolerable biting-stress to cattle or horses when they appear seasonally close to running water.[15]

Simulium (Simulidae, Blackflies)

[to Contents]



Characters: female, lateral. 1- Palps are long, formed of 5 segments. 2- Mouthparts are short, with the piercing elements hidden within the labium when not in use. 3- Antennae are short, without setae and consist of 11 similar segments. 4- Eyes are large relative to rest of body. 5- Thorax is distinctly humped in shape. 6- Thorax and abdomen are mostly without setae, except for the basal scale on the first abdominal segment. 7- Wings have a simple pattern of veins, with several thick veins near the leading edge and only thin veins in the rest of the wing; scales and colored patterns are absent.

Hosts. Livestock species, horses, poultry, humans, and many wild animals are used as hosts.

Signs and disease: These include: irritation, avoidance behavior, biting-stress, dermatitis, and acute allergic reactions to saliva of the feeding flies. These flies swarm around their hosts in daytime. Massive swarms of these flies can directly cause death of livestock from acute stress. Species of simuliids of this and other genera that are important for this stress include: *Cnephia pecuarum*, *Austrosimulium pestilens*, *Simulium arcticum* and *S. ornatum*. In Africa *Simulium* species are vectors of *Onchocerca volvulus* causing human onchocerciasis or River-blindness.[16] Simuliids are biological vectors of *Leucocytozoon* protozoa to poultry birds, and of *Onchocerca gutterosa* and *O. gibsoni* to cattle causing bovine onchocerciasis.

References

1. Smart, J. (1948) *A Handbook for the Identification of Insects of Medical Importance*. London, British Museum (Natural History).
2. Snow, K.R. (1990) *Mosquitoes*. Slough, Richmond Publishing Co. Ltd. ISBN 0-85546-276-0.

3. Edwards, F.W. (1941) *Mosquitoes of the Ethiopian Region*. vol 3, Culicine adults and pupae. London, British Museum (Natural History).
4. Foote R.H. & Cook D.R. (1953) *Mosquitoes of Medical Importance*. Washington, Agricultural Research Service U.S. Department of Agriculture.
5. Gillett, J.D. (1972) *Common African Mosquitos and their Medical Importance*. London, William Heinemann. ISBN 0-433-11750-8.
6. Subramanian, S., et al. (1997) The relationship between microfilarial load in the human host and uptake and development of *Wuchereria bancrofti* microfilaeiae by *Culex quinquefasciatus*: a study under natural conditions. Parasitology, 116: 243-255.
7. Gubler, D.J. (2004) The changing epidemiology of yellow fever and dengue, 1900 to 2003: full circle? Comparative Immunology, Microbiology and Infectious Diseases, 27: 319-330. doi:10.1016/j.cimid.2004.03.013.
8. Edman, J.D. (1971) Host feeding patterns of Florida mosquitoes. 1: *Aedes, Anopheles, Coquillettidia, Mansonia* and *Psorophora*. Journal of Medical Entomology, 8: 687-695. doi: 10.1093/jmedent/8.6.687.
9. Klein, T.A., et al. (1991) Comparative susceptibility of anopheline mosquitoes to *Plasmodium falciparim* in Rondonia, Brazil. The American Journal of Tropical Medicine and Hygiene. 44: 598-603.
10. Gillies, M.T. & De Meillon, B. (1968) *The Anophelinae of Africa South of the Sahara*. Johannesburg, The South African Institute for Medical Research.
11. Kettle, D.S. (1995) *Medical and Veterinary Entomology*. Wallingford: CAB International. ISBN 0-85198-968-3.
12. Anderson, G.S., et al. (1991) *Culicoides obsoletus* as a causal agent of *Culicoides* hypersensitivity (sweet itch) in British Columbia. Journal of Medical Entomology, 28: 685-693. doi.10.1093/jmedent/28.5.685.
13. Du Toit, R.M. (1944) The transmission of Blue-tongue and Horse-sickness by *Culicoides*. Onderstepoort Journal of Veterinary Science and Agricultural Industry. 19: 7-16.
14. Svobodova, M., et al. (2009) Cutaneous leishmaniasis caused by *Leishmania infantum* transmitted by *Phlebotomus tobbi*. International Journal for Parasitology, 39: 251-256. doi:10.1016/j.ijpara.2008.06.016.
14. Freeman, P. & De Meillon, B. (1953) *Simuliidae of the Ethiopian Region*. London, British Museum (Natural History).
16. Fischer, P., et al. (1993) Parasitological and clinical characterization of *Simulium neavei* transmitted onchocerciasis in western Uganda. Tropical Medicine and Parasitology. 44: 311-321.

Horse-flies and similar flies (Diptera)

Characters of brachyceran Horse-flies and Clegs (Tabanidae) and Snipe-flies (Rhagionidae)

[to Contents]

These are typical flies of the sub-Order Brachycera. Their antenna are highly characteristic. These are short, projecting in front of head, and consist of three dissimilar and asymmetric segments, with sparse or no setae, and no arista. The outermost segment has a cylindrical extension with rings (or annulations) that appear like miniature segments.

Photograph shows a typical tabanid fly, with large eyes and wings for strong hunting flight during daytime. The short antennae are typical of brachyceran flies.

Females feed on blood of their hosts, males are not blood-suckers. Larvae inhabit wet soil. Mouthparts are complex with a set of two pairs of piercing and slashing mouthparts, two parts making a blood-sucking tube, and a large labellum adapted for sponging up blood released from the wound. These flies are painful to their hosts and are messy feeders; they often go from host to host in rapid succession, attempting to feed persistently and aggressively. This makes them potential mechanical vectors of many pathogens. *Trypanosoma* protozoa are the most important of these pathogens, but also *Anaplasma* bacteria and filarial nematode worms are transmitted.

[to Contents]

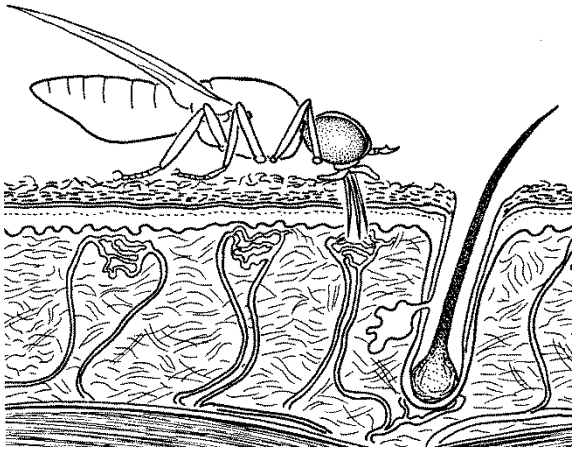


Diagram of feeding at skin represents a tabanid fly cutting into the layer of dermal capillaries of its host to release blood for feeding (proportions are not accurate).

Eyes are exceptionally large relative to head, and on living flies they reflect colored patterns. These flies hunt their hosts during daytime. Legs are medium length and end in two claws, two pulvilli, and a central empodium in the form of a pad.

Thorax and abdomen bear many fine setae, giving a slightly furry appearance, in contrast to the large bristle-like setae of the muscid and calliphorid flies. Wings have complex patterns of venation and in many species there are patterns of light and dark colors; when the fly is at rest the wings are only partly folded over the abdomen.

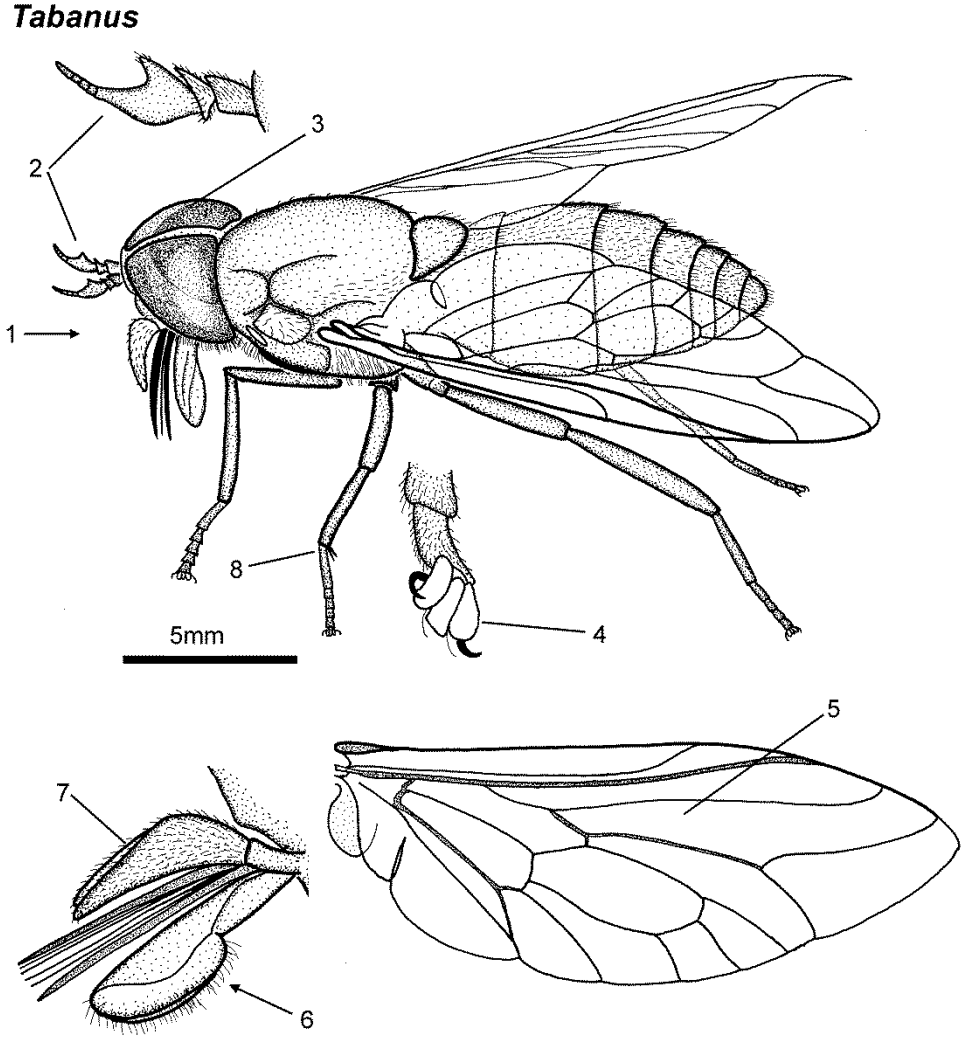
There are many genera of tabanids of veterinary and medical importance; five examples only are described here. The greatest diversity of species and density of populations of tabanids occurs in the Americas, but these flies are widely distributed worldwide. The Snipe-flies belong to a varied Family (Rhagionidae) related to the tabanid group. They are either predatory on other invertebrate animals or feed on the blood of vertebrates, including livestock species.[1,2,3,4]

Glossary

- Annulation = Rings on the outer segment of antenna of some flies; appear similar to small segments (2 on *Chrysops*).
- Antenna = Paired sensory organs on head of insects, sensitive to odors; of characteristic form in brachyceran flies (2 on *Tabanus*).
- Arista = A long thin extension of the outermost segment of the antenna, usually seen on blow-flies and similar (1 on *Symphoromyia*).
- Labellum = A large single component of the mouthparts of brachyceran flies, usually functions to sponge up liquids (6 on *Tabanus*).
- Spur = A stiff and sharp extension of the surface of a leg (8 on *Tabanus*).
- Tibia = The second to outermost segment of legs of arthropods (8 on *Tabanus*).

Tabanus (Tabanidae, Horse-flies)

[to Contents]



Characters: female, lateral and parts. 1- Large and robust tabanids. 2- Antennae have 3 segments of asymmetric shape; the outermost segment has an extension with 4 additional rings or annulations. 3- Eyes have a horizontal pattern, with green and brown colors; gap between the eyes is small; some species have simple eyes (ocelli) between the compound eyes. 4- Legs end with 2 claws, 2 pulvilli and 1 central empodium in form of a pad. 5- Wings are usually clear but may be black overall. 6- Labellum is large; piercing mouthparts are long and finely pointed. 7- Palps consist of 2 segments. 8- Mid-tibiae have spurs; fore- and hind-tibiae have no spurs.

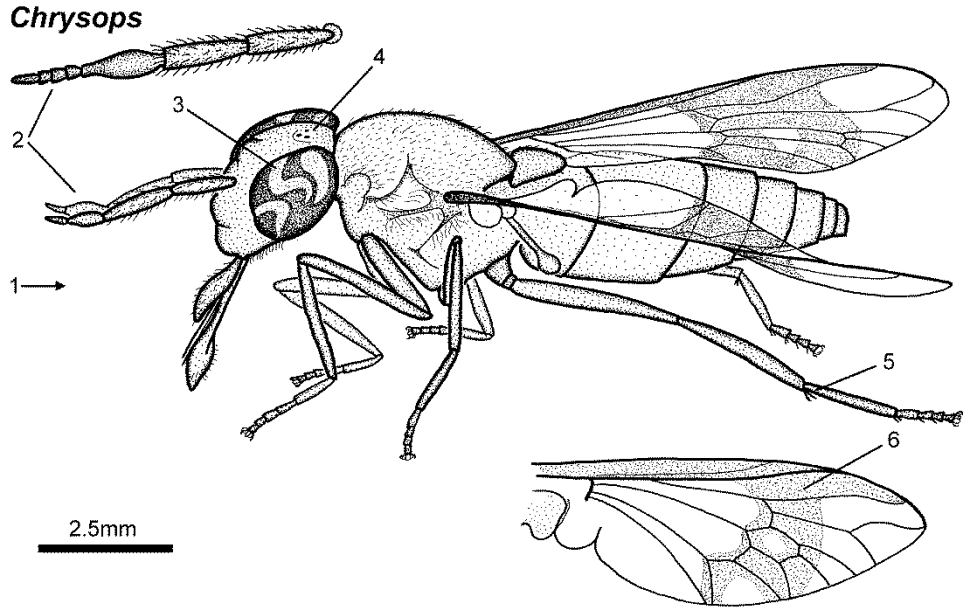
Hosts: *Tabanus* species are commonly known as Horse-flies, Greenheads and similar. They feed on cattle, sheep, goats, horses, camels, and many other mammals including humans.

Signs: Severe irritation and avoidance behavior are caused. Cattle and sheep may pack in a tight circle, all attempting to protect their heads in the center This is a herding defense called Fly-syndrome.

Disease: Numerous *Tabanus* species in North America cause serious biting-stress and blood loss to livestock leading to costly lost production. Important pest species are: *Tabanus atratus* (Black-horsefly) and *T. lineola* (Lined-horsefly), and *T. sulcifrons* (Autumn-horsefly). Species in this genus are mechanical vectors of the protozoans *Trypanosoma evansi* protozoa causing surra, and of *T. vivax* causing nagana.[5]

Chrysops (Tabanidae, Deer-flies)

[to Contents]



Characters: adult, lateral. 1- Small to medium sized tabanids. 2- Antennae are long and the outermost segment has an extension with 4 additional rings. 3- Eyes are relatively small compared to the head, with a wide gap between them; they have patterns of green or red in curved shapes. 4- Simple eyes (ocelli) are present as a group of 3 between the compound eyes. 5- Hind-tibiae have spurs; mid- and fore-tibiae have no spurs. 6- Wings have a black band along the leading edge and across the center.

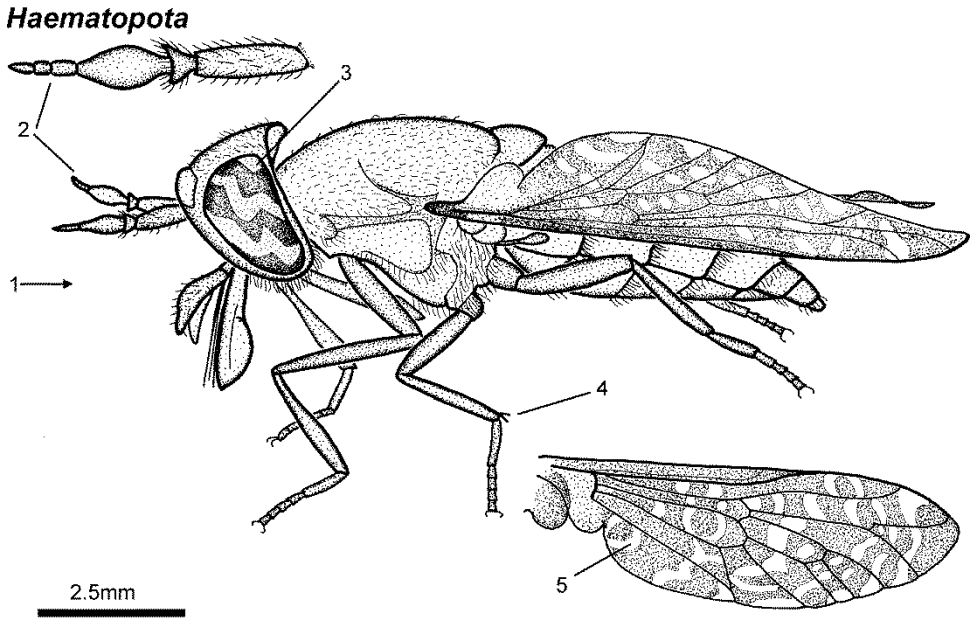
Hosts: *Chrysops* species are commonly known as Deer-flies, but they readily feed on cattle and other livestock animals.

Signs and disease: They cause irritation and biting-stress. Species in this genus are mechanical vectors of the protozoans *Trypanosoma evansi* protozoa causing surra, and of *T. vivax* causing nagana.

[Continued]

Haematopota (Tabanidae, Clegs)

[to Contents]



Characters: female, lateral. 1- Medium sized tabanids. 2- Antennae are medium length, the 3 segments have symmetrical shapes and the extension of the outermost segment has 3 rings. 3- Eyes are medium sized, with a large gap between them; they have a conspicuous angular pattern of red and green. 4- Spurs are present on the tibiae of the mid-legs only. 5- Wings have a complex pattern of pale spots on a grey background.

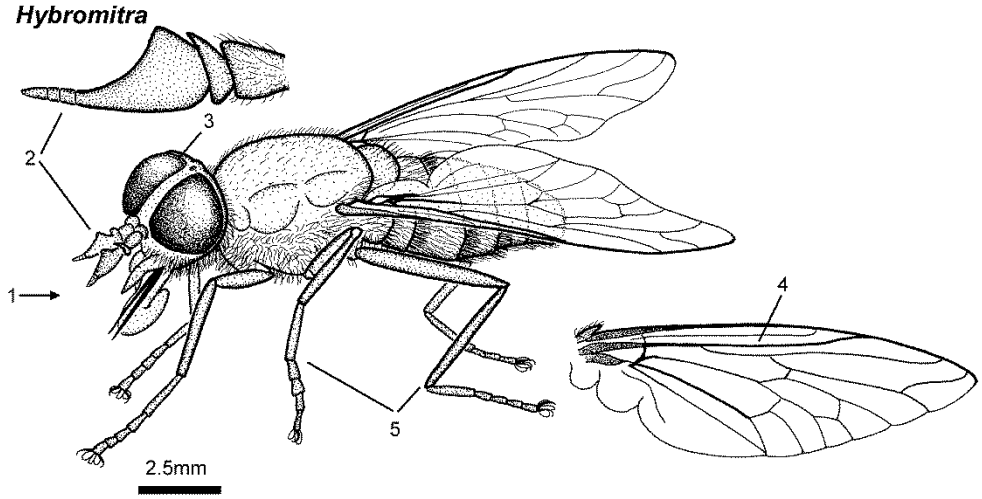
Hosts: These flies are commonly known as Clegs. They feed on cattle and other livestock animals.[6]

Signs and disease: They cause irritation, biting-stress, and they transmit the protozoans *Trypanosoma evansi* causing surra, and *T. vivax* causing nagana.

[Continued]

Hybromitra (Tabanidae, Horse-flies)

[to Contents]



Characters: female, lateral. 1- Large tabanids. 2- Antenna consists of 3 dissimilar segments, the outermost is distinctly asymmetric and its outer extension has 3 rings. 3- Eyes are large, with reflective colors but not distinctly patterned. 4- Wings are clear, without patterns of dark areas. 5- Tibiae of all legs are without spurs.

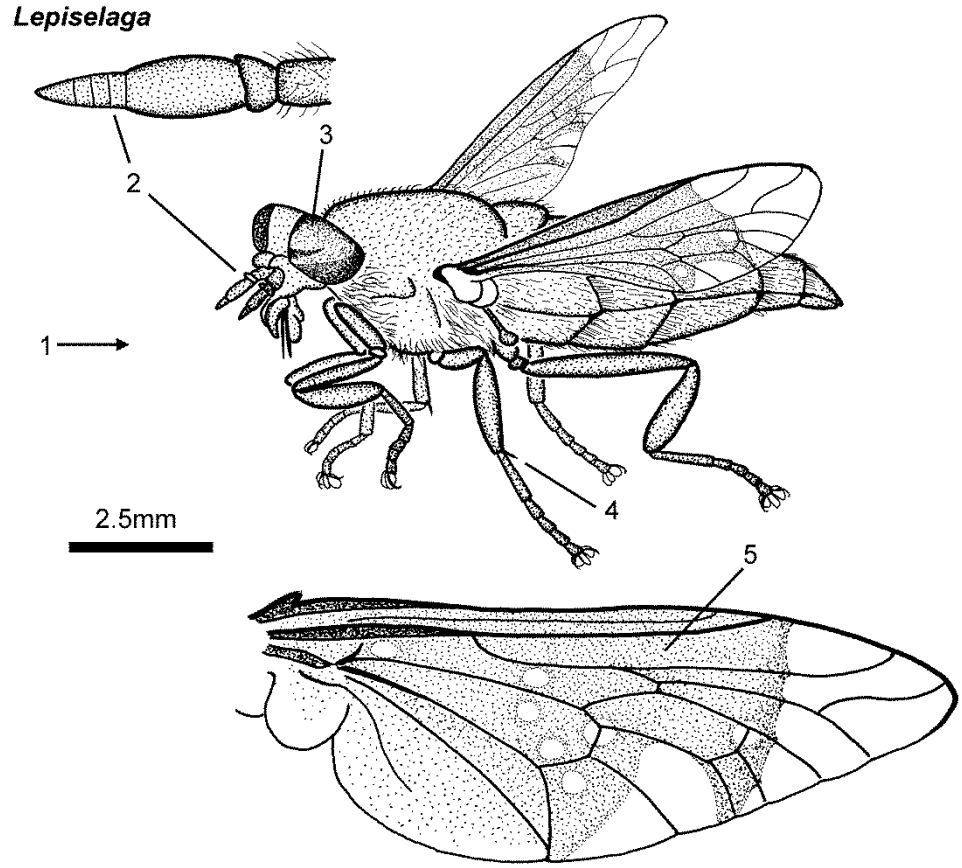
Hosts: Cattle and other livestock species are hosts.

Signs and disease: These are responsible for causing irritation, biting-stress, loss of production, and transmission of the protozoans *Trypanosoma evansi* causing surra, and *T. vivax* causing nagana.

[Continued]

Lepiselaga (Tabanidae)

[to Contents]



Characters: female, lateral. 1- Small tabanids. 2- Antennae consist of 3 symmetrical segments; the extension of the outermost segment has 4 rings. 3- Eyes do not usually have distinct patterns of color. 4- Tibiae of the mid-legs have spurs. 5- Wings have a large basal black band.

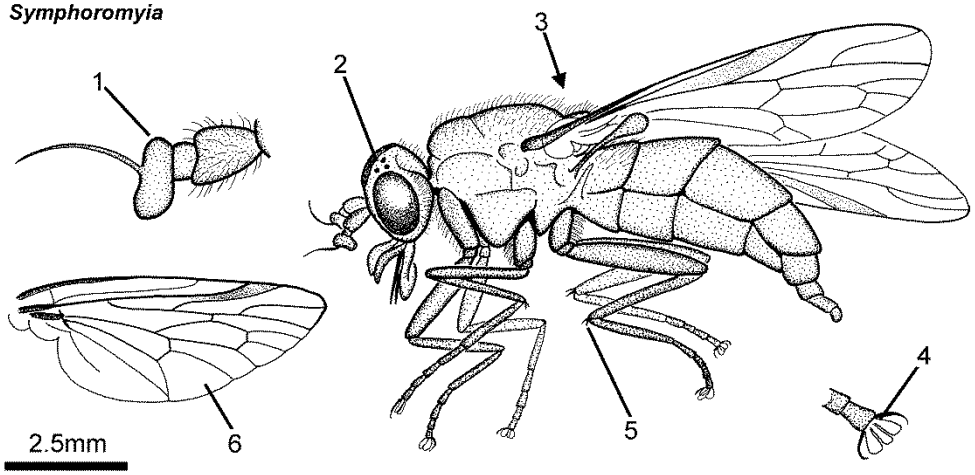
Hosts: Cattle and other livestock animals are hosts.

Signs and disease: These flies cause irritation and biting-stress. They transmit the protozoans *Trypanosoma evansi* causing surra, and *T. vivax* causing nagana.

Distribution: They are restricted to forests of South America.

Symphoromyia (Rhagionidae, Snipe-flies)

[to Contents]



Characters: adult, lateral. 1- Antenna has three segments; the terminal segment is wide and bears a plain arista. 2- Eyes are of medium size and there are three ocelli between the eyes. 3- Body is black, with an elongated abdomen. 4- Hind-legs bear pairs of spurs. 5- Legs each have two pulvilli and a central empodium in the form of a pad. 6- Wings have venation pattern typical of brachyceran flies.

Hosts and disease: The genus *Symphoromyia* represents here a varied group of flies, often known as Snipe-flies, some of which are adapted for feeding on the blood of vertebrates, included livestock animals. They are not known as transmitters of pathogens to livestock.

References

1. Oldroyd, H. (1952) *The Horse-flies of the Ethiopian Region, Vol 1. Haematopota and Hippocentrum*. London, British Museum (Natural History).
2. Oldroyd, H. (1954) *The Horse-flies of the Ethiopian Region, Vol 2. Tabanus and related genera*. London, British Museum (Natural History).
3. Austen, E.E. (1909) *Illustrations of African Blood-sucking Flies other than Mosquitoes and Tsetse-flies*. London, British Museum.
4. Edwards, F.W., et al. (1939) *British Blood-sucking Flies*. London, British Museum (Natural History).
5. Reid, S.A. (2002) *Trypanosoma evansi* control and containment in Australasia. Trends in Parasitology, 18: 219-224.
6. Dickerson, G. & Lavoipierre, M.M.J. (1959) Studies on the methods of feeding of blood-sucking arthropods: III.—The method by which *Haematopota pluvialis* obtains its blood-meal from the mammalian host. Annals of Tropical Medicine & Parasitology. 53: 465-472.

House-flies, Stable-flies and similar flies (Diptera)

Characters of a group of non-biting flies and biting flies (sub-order Brachycera)

[to Contents]

These flies are all are brachycerans, with short antennae of a few dissimilar segments. The antennae consist of three short segments that lie in a groove in the head, and the large outermost segment has a distinct extension as an arista.

Most species in this group are free-living, but there are many ways some of them have adapted to parasitism. Adaptations of mouthparts of these flies often do not correspond with the taxonomic position of the fly. Mouthparts vary from surface sponging type (as with *Musca*) to a skin-piercing proboscis (as with *Stomoxys*)

Photograph shows a live Stable-fly, genus *Stomoxys*, with large eyes, characteristic short antennae, one pair of powerful wings, and long piercing mouthparts projecting forward from head. (Photograph by Pavel Krok).

The life-cycle of most flies in this group is a simple complete metamorphosis, with eggs laid in the external habitat of the larvae such as organic waste, pupation in the same habitat, and adults parasitic on domestic animals. However, the Tsetse-flies are specialized for high survival of their larvae by rearing them one at a time.

House-flies and similar flies (Muscidae) are the familiar muscid flies common around human housing and livestock enclosures. The Eye-flies (Chloropidae) consist of several genera of small flies that cluster at the head and eyes of livestock animals, feeding on tears and mucous secretions; one example genus is described here. Stable-flies and Horn-flies (Muscidae) and Tsetse-flies (Glossinidae) are typical muscid flies in general structure and

appearance, often superficially similar to *Musca* species. (Note that former genera *Lyperosia* and *Haematobosca* are now merged with *Haematobia*).

Mouthparts of Stable-flies, Horn-flies and Tsetse-flies are adapted for piercing the host's skin to feed on blood. These mouthparts are conspicuous as a stout proboscis that projects forwards; the labellum is not adapted as a sponging organ. These flies search for hosts during daytime; both females and males feed on blood.

The life-cycle of Stable-flies and Horn-flies is a normal complete metamorphosis type with free living larvae. The life-cycle of Tsetse-flies is highly adapted to blood-feeding parasitism. Both sexes feed exclusively on blood. A female takes repeated feeds to support development of one larva at one time within its oviduct. The mature larva is laid on sandy soil, where it rapidly burrows then pupates (see photograph under genus *Glossina*). The female repeats this larviparous method of reproduction to sustain the population[1,2,3,4,5]

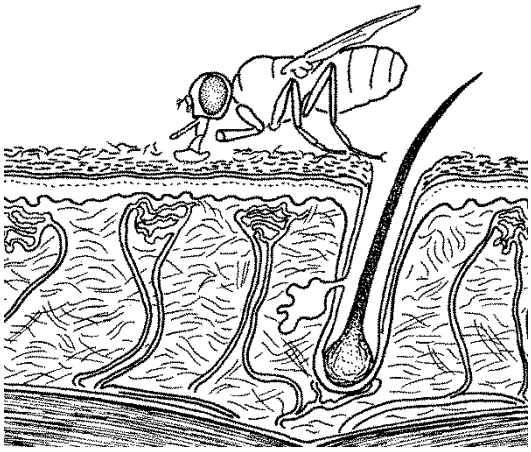


Diagram of feeding at skin represents surface sponging by House-flies and others. There are no piercing elements in the mouthparts but some species have small rasping teeth within the sponge structure.

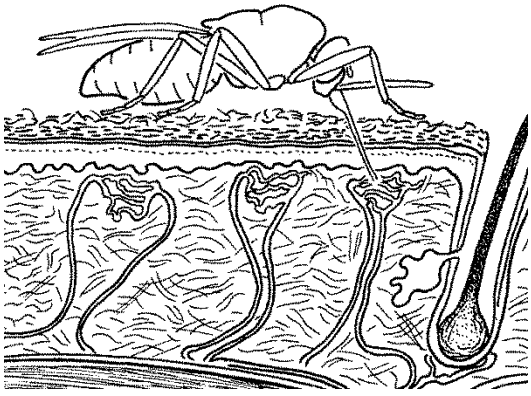


Diagram of feeding at skin represents the blood feeding by Stable-flies, Horn-flies or Tsetse-flies, by piercing into dermal capillaries with a stout proboscis type of mouthparts.

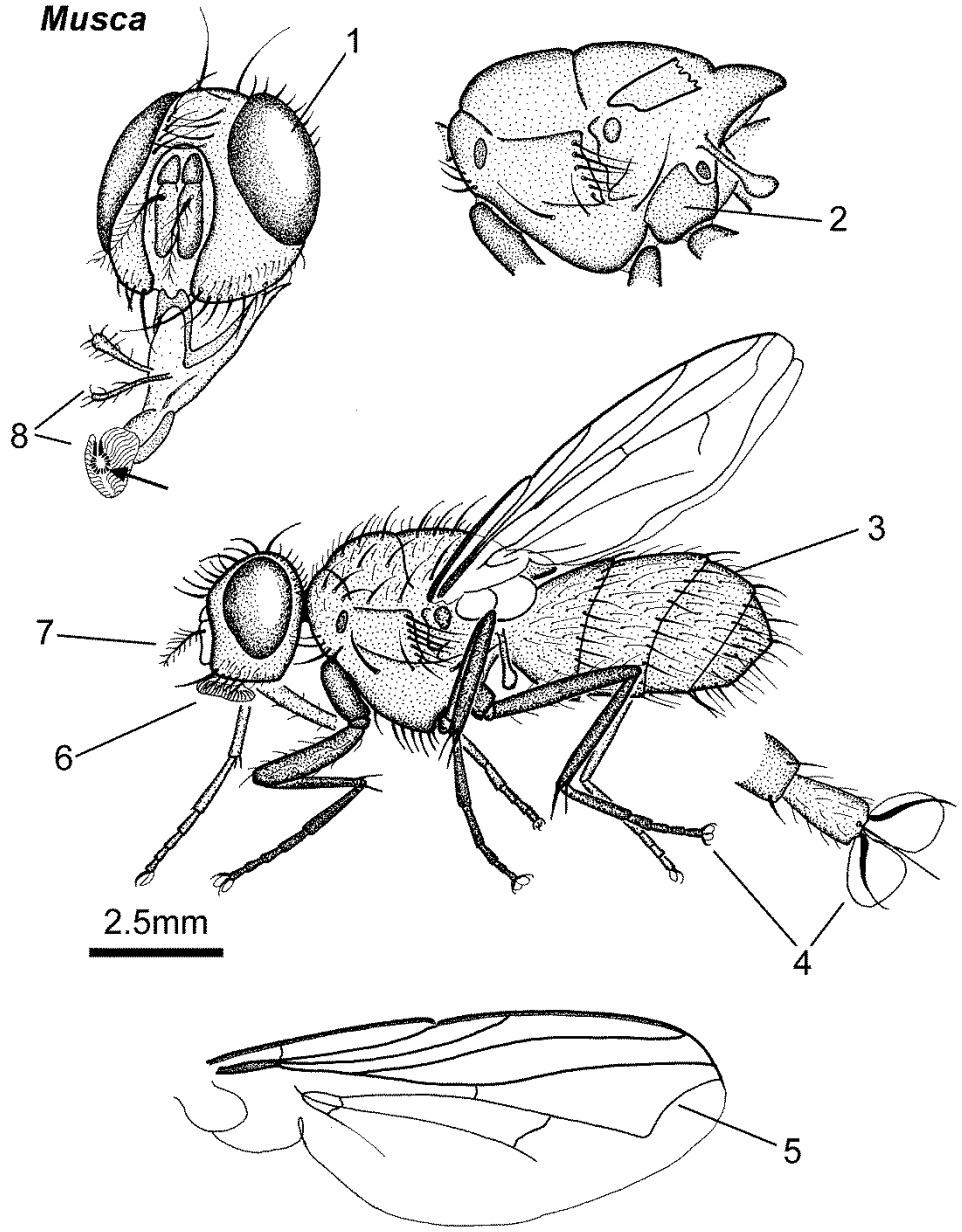
Glossary

- Arista = A thin extension of the outermost segment of the antenna, it may have additional fine setae giving an appearance like a feather (7 on *Musca*).
- Discal cell = An area of the wing defined by veins and forming a characteristic angular shape (6 on *Glossina*).
- Empodium = A thin extension like a seta at the end of the feet, between the pulvilli (4 on *Musca*).
- Hypopleuron = A specific area of the thorax of flies; in this group of flies it is without a row of setae, but with setae in Blow-flies such as *Calliphora*.
- Labellum = A paired organ (two labella lobes) at end of labium of the mouthparts of dipteran flies; well developed in muscid and tabanid flies where they are used like a sponge for feeding; or small and sharp as in *Stomoxys* where they are piercing organs (6 on *Musca* or 7 on *Stomoxys*).
- Larvipary = Reproduction by giving birth to a mature larva which developed from an egg retained in the female's oviduct.
- Prestomal teeth = small rasping teeth at the tip of a sponging labellum (8 on *Musca*).
- Proboscis = General term for mouthparts of an insect that combine to form a stout piercing organ (9 on *Haematobia*).
- Pulvillus = Pads on the ends of legs of insects and acarines, with adhesive properties (4 on *Musca*).
- Tibia = Second to outermost segment on legs, may be equipped with a spur (5 on *Hippelates*).
- Vein 4 = A wing vein that has a shape characteristic of genera of dipteran flies (5 on *Musca*).

[Continued]

Musca (Muscidae, House-flies)

[to Contents]



Characters: adult, lateral. 1- Eyes are large and dull red/brown. 2- Thorax does not have on its hypopleuron a row of stout setae (compare with *Calliphora* in Blow-flies); thorax is dull black with four dorsal grey stripes. 3- Abdomen shows 4 visible segments (other segments are concealed at posterior); abdomen is dull mid brown. 4- Ends of the legs consist of a pair of claws, a pair of pulvilli, and a central empodium as a fine seta. 5- Wings have vein 4 curving sharply up towards the leading edge. 6- Mouthparts fold underneath the head when not in use. 7- Arista has setae on both sides. 8- Mouthparts extended for use reveal a labellum (sponging organ) and a pair of small palps. Also: arrow points to prestomal teeth between lobes of the labellum.

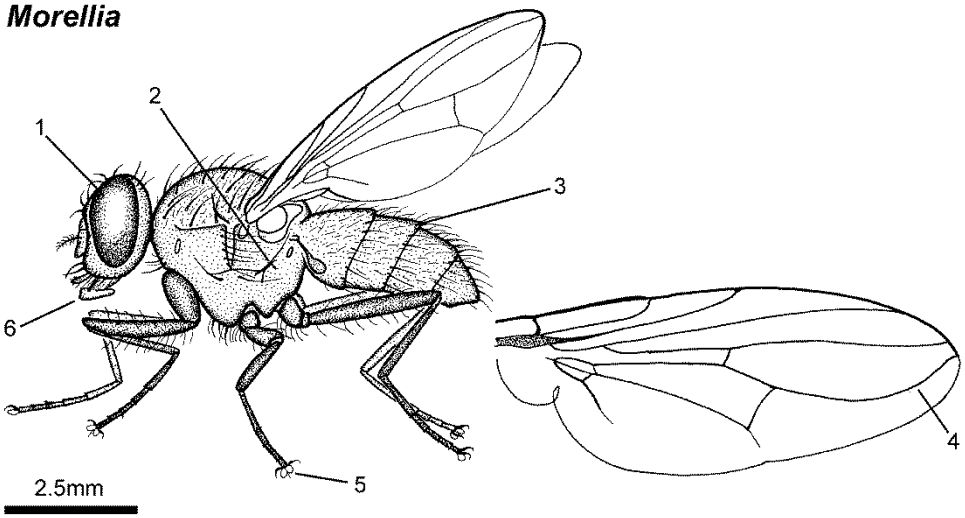
Hosts: *Musca domestica* (House-fly), *M. autumnalis* (Face-fly), *M. sorbens* (Bazaar-fly) *and M. vetustissima* (Bush-fly) are examples of the large

number of species that feed on cattle, sheep and goats, pigs, horses, camels, humans and other mammals. Feeding is by sponging up wet secretions at the mouth, nostrils, eyes, teats, edge of wounds, and elsewhere. The ring of prestomal teeth at the end of the labellum may be used by some species to scrape at the skin surface to yield exuding liquid.[6]

Disease: Nuisance through to severe irritation, leads to avoidance behavior. There is mechanical transmission of many types of microbial pathogens involved in mastitis. *Moraxella bovis* bacteria causing keratoconjunctivitis (Pink-eye) are transmitted to cattle by *M. autumnalis* which feed at the mouth and eyes.[7] *Musca* species also transmit nematode worms: *Habronema* to horses, *Thelazia* to cattle and horses, and *Parafilaria* to cattle. Larvae of muscid flies typically inhabit dung piles and similar decomposing material, and the adult flies will feed on liquids there. Hence the wide variety of potential pathogens associated with these flies.

Morellia (Muscidae, Sweat-flies)

[to Contents]



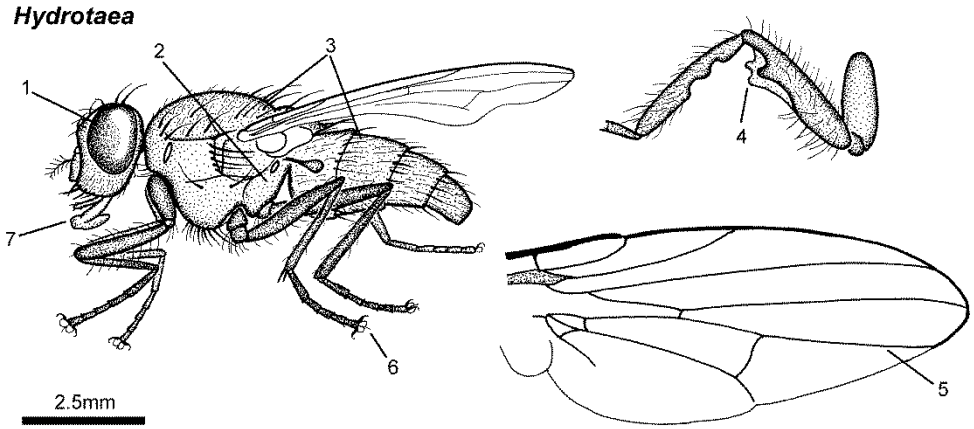
Characters: adult, lateral. 1- Eyes are large and red/brown. 2- Thorax has its hypopleuron without a row of stout setae; thorax is black with dorsal grey stripes. 3- Abdomen shows four visible segments (other segments are concealed at posterior); dorsal abdomen is dull black, but white ventrally. 4- Wings have vein 4 curving evenly up towards outermost leading edge. 5- Ends of the legs consist of a pair of claws, a pair of pulvilli, and a central empodium as a fine seta. 6- Mouthparts when extended reveal the labellum (in form of a sponging organ) and a pair of small palps. Also: these flies are very similar to *Musca* but the body color and the shape of wing veins distinguish them.

Hosts: These Sweat-flies swarm around cattle and sheep seeking surface liquids to feed on.

Disease: Severe nuisance is caused.

Hydrotaea (Muscidae, Head-fly)

[to Contents]

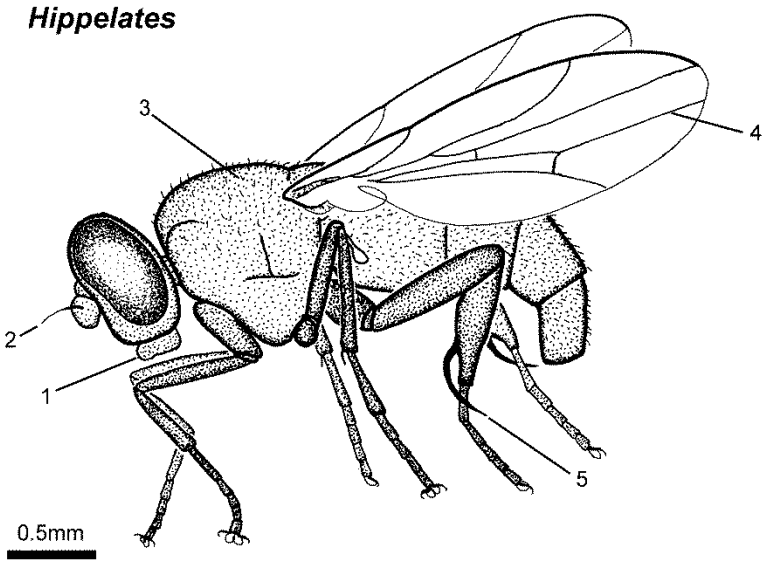


Characters: adult, lateral. 1- Eyes are large and red/brown. 2- Thorax has its hypopleuron without a row of stout setae. 3- Thorax and abdomen are dull black/green. 4- Fore-legs have a set of notches on their two largest segments. 5- Wings have vein 4 curving slightly towards outermost trailing edge. 6- Ends of the legs consist of a pair of claws, a pair of pulvilli, and a central empodium as a fine seta. 7- Mouthparts when extended for use reveal the labellum (in form of a sponging organ) and a pair of small palps.

Hosts: *Hydrotaea irritans* (Sheep head-fly) feeds on sheep and cattle at their mouth, nostrils, eyes and base of horns. This species has well developed prestomal teeth which they will use to scrape at the edge of skin wounds to release blood to feed on.

Disease: Irritation to severe biting-stress is caused by the feeding activity. Transmission of bacteria causing mastitis in cattle occurs.[8]

Hippelates (Chloropidae, Eye-flies)



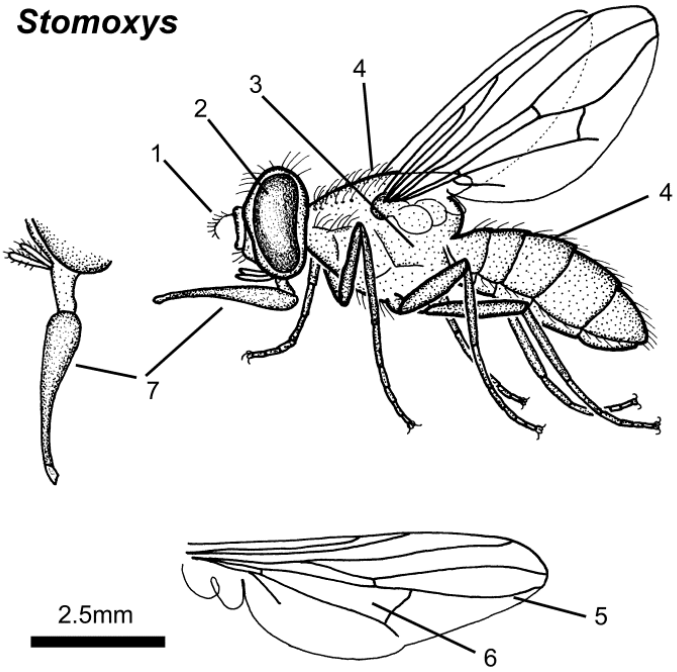
Characters: adult, lateral. 1- Mouthparts are adapted for sponging. 2- Antenna has a spherical third segment which bears a prominent arista without setae. 3- Thorax and abdomen have only small setae,

none of them resemble bristles; color is dull brown. 4- Vein 4 of wing goes directly to the outermost edge. 5- Tibiae of the hind legs have a prominent spur projecting backwards.

Hosts: Cattle, sheep and goats are troubled by these Eye-flies.
Signs and disease: Irritation is caused and there is potential for contaminative transmission of bacteria causing conjunctivitis.

Stomoxys (Muscidae, Stable-flies)

[to Contents]

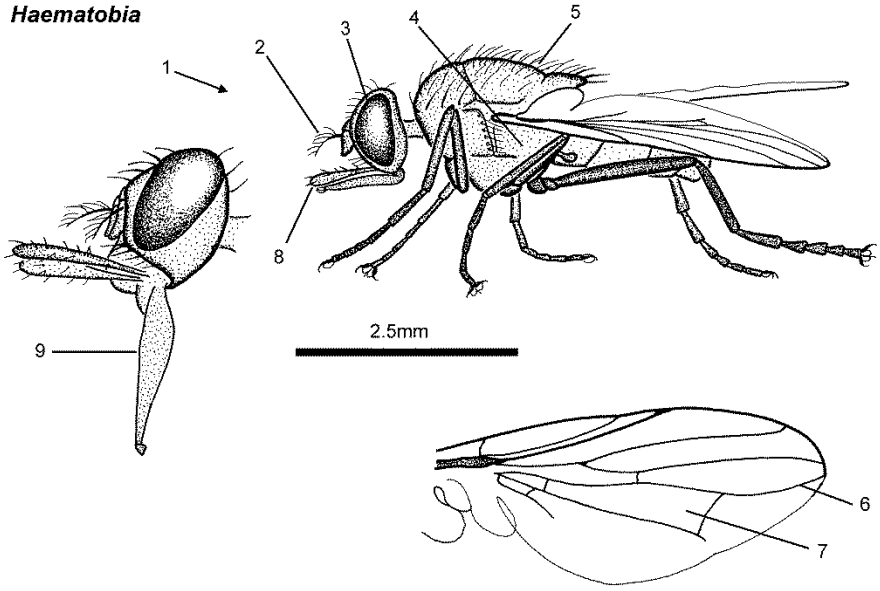


Characters: adult, lateral. 1- Antenna has arista with short setae on the dorsal surface only. 2- Eyes are large and mid brown. 3- Thorax has a hypopleuron without a row of stout setae. 4- Thorax is colored black with prominent dorsal grey stripes; abdomen has a mottled pattern of grey and black dorsally, but is pale yellow ventrally. 5- Wing has vein 4 that curves evenly toward the lower outermost edge. 6- Wing has a discal cell of fairly symmetrical, trapezoid, shape. 7- Mouthparts project forward as a single proboscis when not in use; palps are much shorter than the proboscis.

Hosts: *Stomoxys calcitrans* (Stable-fly) and *S. niger* feed mainly on cattle and other bovids, preferring the legs and back. Stable-flies also feed on dogs, at their ears.[9]
Signs and disease: Irritation leads to leg shaking and stamping. Biting-stress leads to substantial loss of production, particularly to dairy cattle when near the larval habitats.

Haematobia (Muscidae, Horn-flies)

[to Contents]



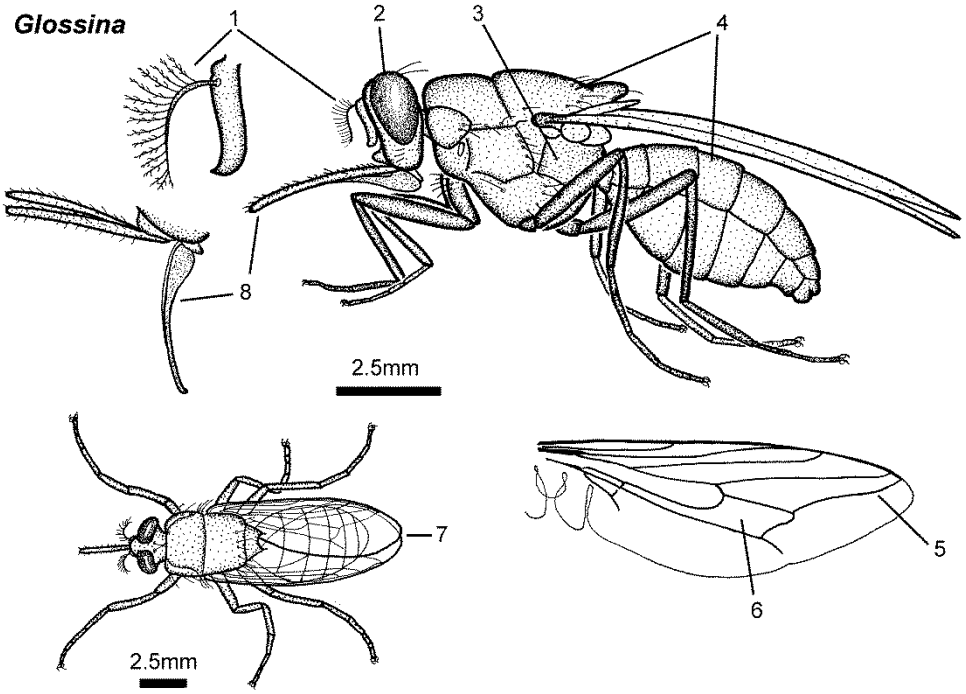
Characters: adult, lateral. 1- Similar to *Stomoxys* but approximately half that size. 2- Antenna has arista with short setae on the dorsal surface only. 3- Eyes are large and red/brown. 4- Thorax has a hypopleuron without a row of stout setae. 5- Thorax and abdomen are dull light brown. 6- Wing has vein 4 that curves evenly toward the lower outermost edge. 7- Wing has a discal cell of fairly symmetrical, trapezoid, shape; wings are held at an angle to the body when the flies are feeding forming a reflective angular shape. 8 and 9- Palps are as long as proboscis; mouthparts project forward as a single proboscis when not in use.

Hosts: *Haematobia irritans* (Horn-fly) feeds mainly on cattle and buffalo, taking repeated small feeds during the day.

Signs and disease: These flies cause irritation, biting-stress, and avoidance behavior, leading substantial loss of production when these flies accumulate in massive numbers around cattle.[10]

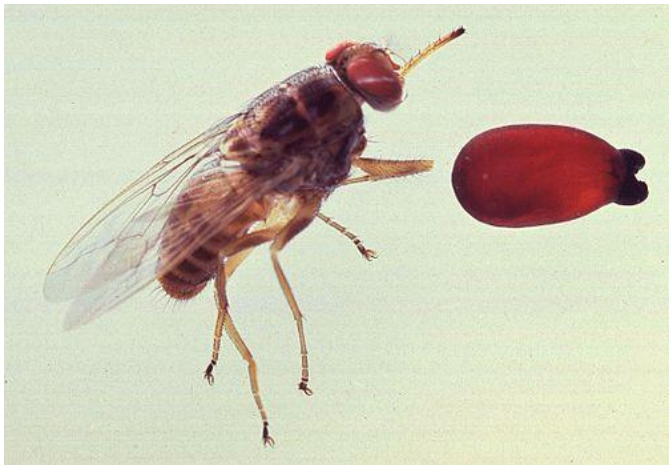
[Continued]

Glossina (Glossinidae, Tsetse-flies, or Tsetse) [to Contents]



Characters: adult, lateral. 1- Antennae have an arista with setae on the dorsal surface; these setae have additional extensions, making the arista look like a feather. 2- Eyes are dark brown. 3- Thorax has a hypopleuron without a row of stout setae. 4- Thorax and abdomen are dull light brown/grey in mottled patterns. 5- Wings have vein 4 curving in a wavy line toward the outer leading edge. 6- Discal cell of wings is distinctly asymmetric, shaped like an axe or hatchet. 7- When resting, wings are folded flat and overlapping. 8- Palps are as long as the piercing proboscis; the proboscis projects forwards when not in use.

Hosts: Cattle, a wide range of wild bovids, warthogs and other pigs sustain populations of these flies. Humans in endemic areas are readily bitten by these aggressive flies (which are also correctly known simply as Tsetse).
Disease: Blood-feeding by these large flies is painful but loss of livestock productivity by biting-stress is poorly known. Tsetse-flies are notorious as the biological vectors of the *Trypanosoma* species of protozoa that cause nagana in cattle and sleeping-sickness in humans.
Distribution: Tsetse-flies are widely distributed in sub-Saharan Africa, but nowhere else. The species of importance to health, such as *G. morsitans* and *G. pallidipes*, mainly inhabit dry wooded savannah.[11]



Photograph shows an adult female Tsetse-fly (*Glossina*) and a puparium that the fully mature pupa formed rapidly after being laid by a female.

References

1. Zumpt, F. (1973) *The Stomoxyine Biting Flies of the World*. Stuttgart, Gustav Fischer Verlag.
2. Leak, S.G.A. (1999) *Tsetse Biology and Ecology*. Wallingford, England, CABI Publishing. ISNB 0-85199-300-1.
3. Coetzer, J.A.W. (1994) *Infectious Diseases of Livestock with Special Reference to Southern Africa*. Cape Town: Oxford University Press. ISBN 0-19-570506-8.
4. Lancaster, J.L. & Meisch, M.V. (1986) *Arthropods in Livestock and Poultry Production*. Chichester: Ellis Horwood Ltd. ISBN 0-85312-790-5.
5. Williams, R.E. (2010) *Veterinary Entomology: Livestock and Companion Animals*. Boca Raton, CRC Press.
6. Hughes, R. D., et al. (1972) A synopsis of observations on the biology of the Australian bushfly (*Musca vetustissima* Walker). Australian Journal of Entomology. 11: 311-331.
7. Glass, H.W. & Gerhardt R.R. (1984) Transmission of *Moraxella bovis* by regurgitation from the crop of the face fly (Diptera: Muscidae). Journal of Economic Entomology ,77: 399-401.
8. Hillerton, J. E., et al. (1983) *Hydrotaea irritans* and summer mastitis in calves. Veterinary Record 113: 88-88. doi:10.1136/vr.113.4.88.
9. Torr, S. J. et al. (2006) The effects of host physiology on the attraction of tsetse (Diptera: Glossinidae) and *Stomoxys* (Diptera: Muscidae) to cattle. Bulletin of Entomological Research 96: 71-84. doi:10.1079/.p.
10. Guglielmone, A.A., et al. (1999) Skin lesions and cattle hide damage from *Haematobia irritans* infestations. Medical and Veterinary Entomology, 13: 324-329. doi:10.1046/j.1365-2915.1999.00167.x.
11. Harley, J.M.B. & Wilson. A.J. (1968) Comparison between *Glossina morsitans, G. pallidipes* and *G. fuscipes* as vectors of trypanosomes of the *Trypanosoma congolense* group: the proportions infected experimentally and the numbers of infective organisms extruded during feeding. Annals of Tropical Medicine & Parasitology 62: 178-187. doi:10.1080/00034983.1968.

Blow-flies and similar flies (Diptera, Calliphoridae)

Characters of Blow-flies, Screw-worm flies, and Flesh-flies

These calliphorid flies are large, stout, and their body bears many long thick setae in the form of bristles. The body surface is like polished metal colored blue, green or black. Wings are usually clear and always have a full network of veins over their surface. Mouthparts of adults are always of the sponging type, without piercing parts. The adults feed on liquids from their hosts or environment, and they do not pierce host skin to suck up blood.[1]

Photograph shows a *Chrysomya* Screw-worm adult fly and mature larva (preserved). The sponging type of mouthparts hang down below the head. The colors of a live fly would show as red/brown eyes and shiny blue/green abdomen.

The larvae are usually the stage related to disease, causing either facultative myiasis (an optional infestation) or obligate myiasis (an essential infestation). Most infestations with these larvae are one of three types: a mass of larvae abrade and feed at surface of skin; a mass of larvae burrow vertically into skin; single larvae develop as furuncles (like boils) in the skin. Usually these larvae look similar to the free living maggots typical of the muscid flies, with segmental bands of spines and rasping mouthparts. The shape and patterns of the posterior spiracles are crucial for identification. The posterior spiracles of calliphorid larvae usually have a trio of slits surrounded by a peritreme. This contrasts with posterior spiracles of oestrid larvae which form a pair of large flat plates with numerous small openings (see Botflies). The life-cycle is a normal complete metamorphosis, with three larval stages and a free living pupa.

[to Contents]

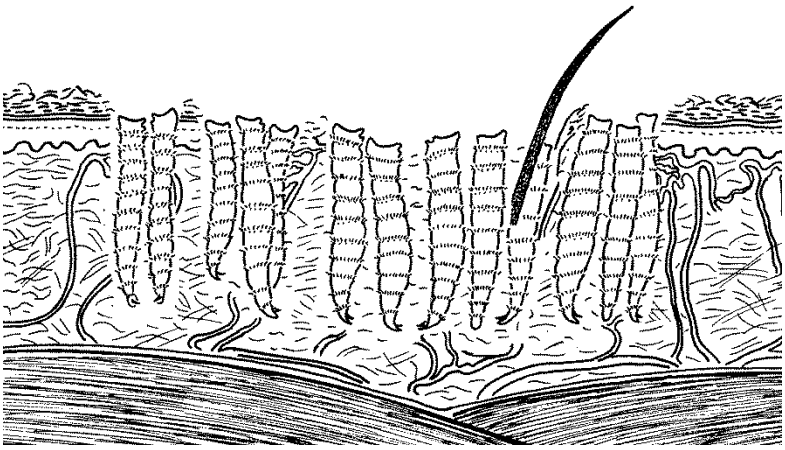


Diagram of feeding at skin represents a superficial infestation by immature larvae of a Screw-worm fly. The proportions larvae to skin are not accurate.

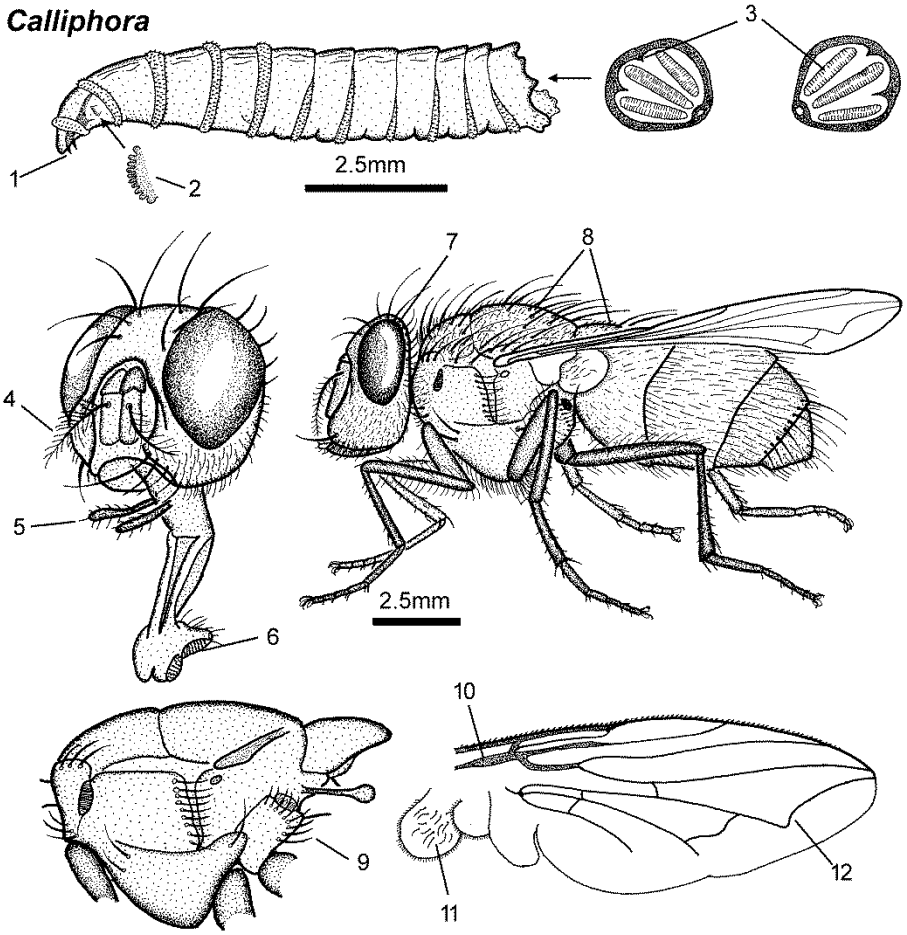
There are many genera and species of parasitic calliphorid flies. Some of them are highly host specific, for example *Elephantoloemus indicus*, whose larvae burrow in the skin of Asian elephants. Only those mostly commonly causing disease to domestic animals and people are included here.

Glossary

- Facultative myiasis = This type of myiasis caused by flesh-eating larvae is not essential to the reproduction and survival of the fly population; the eggs may be laid on carrion and other rotting material and develop there.
- Furuncle = An abscess or boil-like development in the skin of a host animal where a single myiasis larva is developing.
- Hypopleuron = An area like a plate on the lower posterior side of the thorax, that may or may not have a row of setae (9 on *Calliphora*).
- Labellum = This organ of the mouthparts of dipteran flies is in the form of a sponge in Blow-flies and similar (6 on *Calliphora*).
- Maggot = General vernacular term for larvae of muscid and calliphorid flies; usually free living larvae but also refers to larvae causing myiasis.
- Peritreme = A sclerotized area around the posterior spiracles of dipteran larvae (3 on *Calliphora*).
- Spiracle = Opening of the respiratory system of insects and acarines; anterior and posterior spiracles occur on dipteran larvae (2 and 3 on *Calliphora*).
- Stem vein = A thick vein at the base of wings of dipteran flies (10 on *Calliphora*).
- Strike or Blowfly strike = Vernacular name for the type of superficial myiasis caused by *Lucilia* and similar Blow-flies.

Calliphora (Calliphoridae, Blow-flies)

[to Contents]



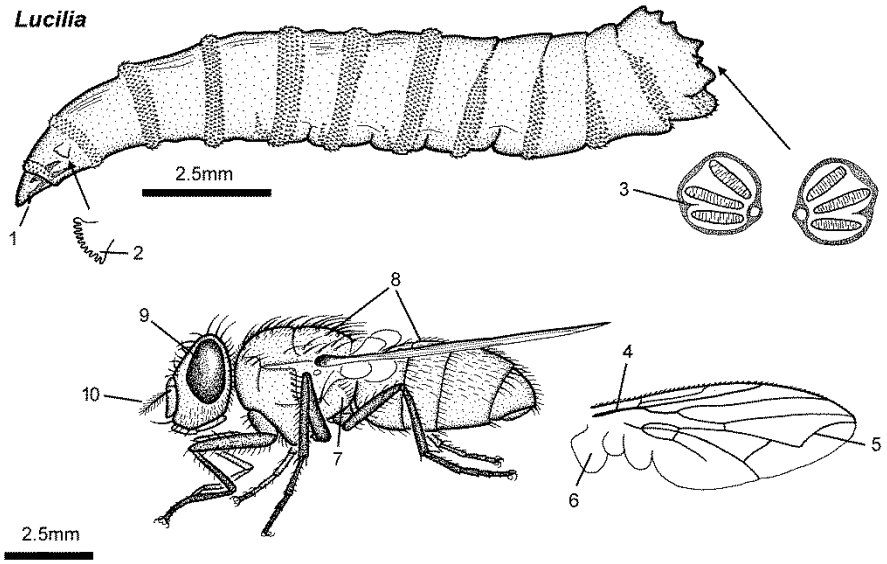
Characters: larva, adult, lateral. 1- Rasping mouthparts of larva. 2- Anterior spiracle has eight to ten openings. 3- Posterior spiracles have a thick peritreme with two internal projections, and 3 openings as long ovals. 4- Antenna has large arista with setae on both sides. 5- Palps are short relative to the labium of the mouthparts. 6- Mouthparts have a sponging labellum, without piercing parts. 7- Eyes are dark brown. 8- Thorax and abdomen are usually shiny dark blue but some species are mid brown; also bristle-like setae on thorax are conspicuously long. 9- Thorax has on its hypopleuron a row of stout setae (compare with *Musca* in Houseflies). 10- Wings have stem veins without a row of stout seta. 11- Thoracic squama of the wing bears long thin setae. 12- Vein 4 is angled sharply up toward the outermost edge.

Hosts: Sheep may be infested with larvae.

Signs and disease: Larvae of *Calliphora* species sometimes cause superficial myiasis in the skin of sheep, contributing to the disease often known as Blowfly-strike. The larvae burrow into the skin head first, exposing just their spiracles to the surface.[2]

Lucilia (Calliphoridae, Blow-flies)

[to Contents]



Characters: larva, adult, lateral. 1- Rasping mouthparts of larva. 2- Anterior spiracle has 7 to 10 openings. 3- Posterior spiracles have a thick peritreme with one internal projection. 4- Wings have stem veins without a row of stout setae. 5- Vein 4 is angled sharply up toward the outermost edge. 6- Thoracic squama bears no setae on its upper surface. 7- Thorax has on its hypopleuron a row of stout setae. 8- Thorax and abdomen are metallic bright green. 9- Eyes are mid brown. 10- Antenna has a large arista with setae on both sides.

Hosts: Sheep, and other domestic animals, may be infested. Female flies, commonly *Lucilia sericata* and *L. cuprina*, may lay eggs at sites on skin that are already wounded, or contaminated with feces, or sites infected with *Dermatophilus congolensis* bacteria, or similar infections. *Lucilia* species are facultative parasites, and the adults cause no direct harm.[2]

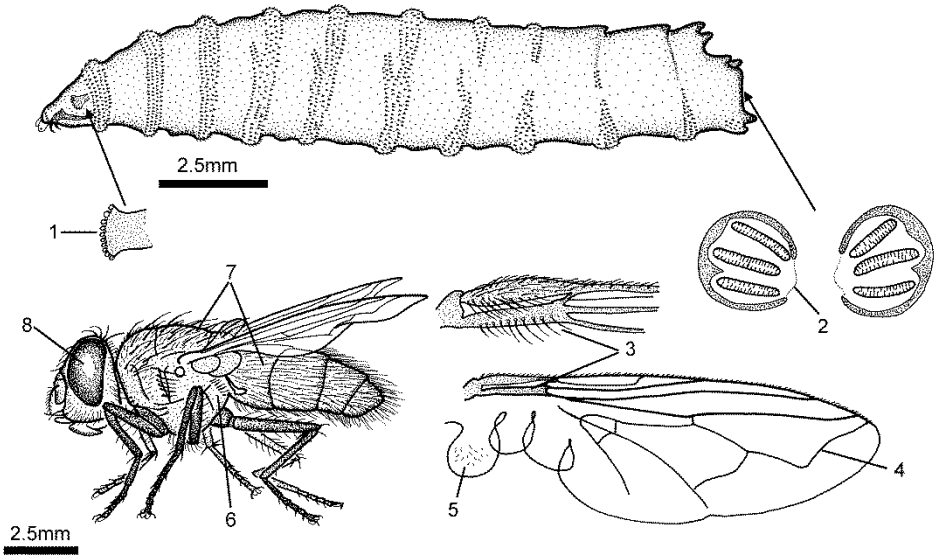
Signs: Infestations of larvae are superficial on the skin, with the larvae not burrowing down into the dermis. An infestation resulting from a single egg batch will produce a wide and bloody lesion infested by several hundred mature maggots.

Disease: Blowfly-strike by *Lucilia* species causes pain, stress, hide-damage, and anemia. In severe cases an acute and potentially fatal toxemia develops due to ammonia excreted by the larvae. These blowflies can cause serious loss of production for sheep farmers.

Phormia (Calliphoridae, Blow-flies)

[to Contents]

Phormia



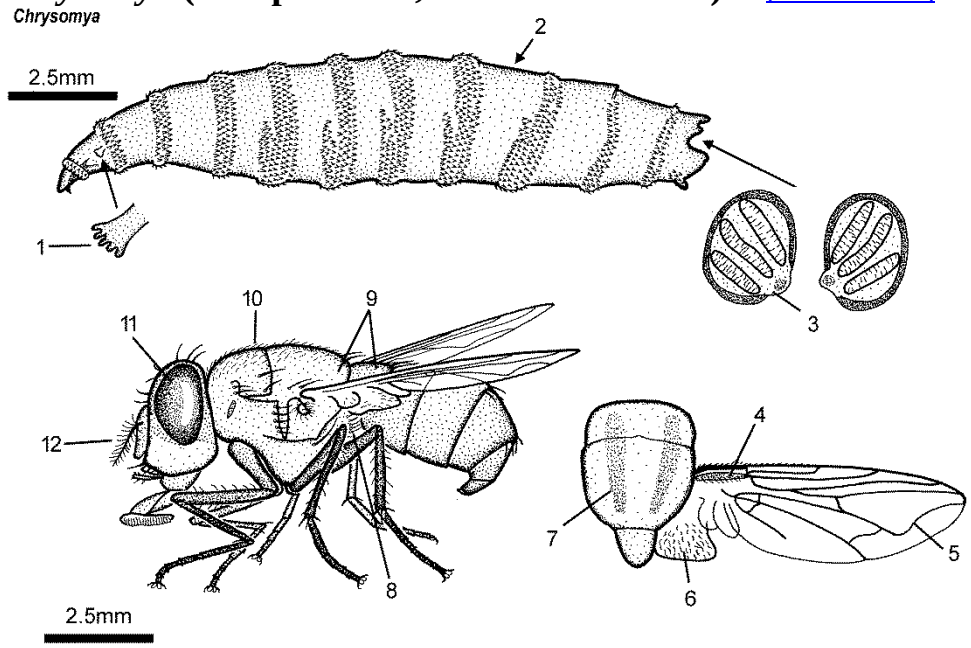
Characters: larva, adult, lateral. 1- Anterior spiracle has up to 10 openings. 2- Posterior spiracles have a thick peritreme, but it does not form a complete circle. 3- Wings have stem veins with a row of stout seta. 4- Vein 4 is angled sharply up toward the outermost edge. 5- Thoracic squama bears faint white setae on its upper surface. 6- Thorax has on its hypopleuron a row of stout setae. 7- Thorax and abdomen are metallic dark blue or dark green. 8- Eyes are mid brown.

Hosts: *Phormia regina* is another species that may contribute to Blowfly-strike on sheep. It is a facultative parasite.

Signs and disease: As for *Lucilia*, however *Phormia* flies are less common than *Lucilia* in their role as a cause of myiasis.

[Continued]

Chrysomya (Calliphoridae, Screw-worm flies) [to Contents]



Characters: larva, adult, lateral. 1- Anterior spiracles have from 4 to 13 openings. 2- Some species have larvae with many fleshy tubercles projecting from most segments, other species are smooth between the bands of spines, as shown here. 3- Posterior spiracles have a peritreme that is incomplete. 4- Stem vein of wing has a row of setae. 5- Vein 4 of wing is angled sharply up toward the outermost edge. 6- Thoracic squama is large, angular and white, and it has setae on its upper surface. 7- Dorsal surface of thorax has stripes slightly darker than their background. 8- Hypopleuron of thorax has a row of stout setae. 9- Thorax and abdomen are metallic green or blue/green. 10- Setae on top of thorax are relatively short. 11- Eyes are red/brown or orange. 12- Antenna has arista with setae on both sides.

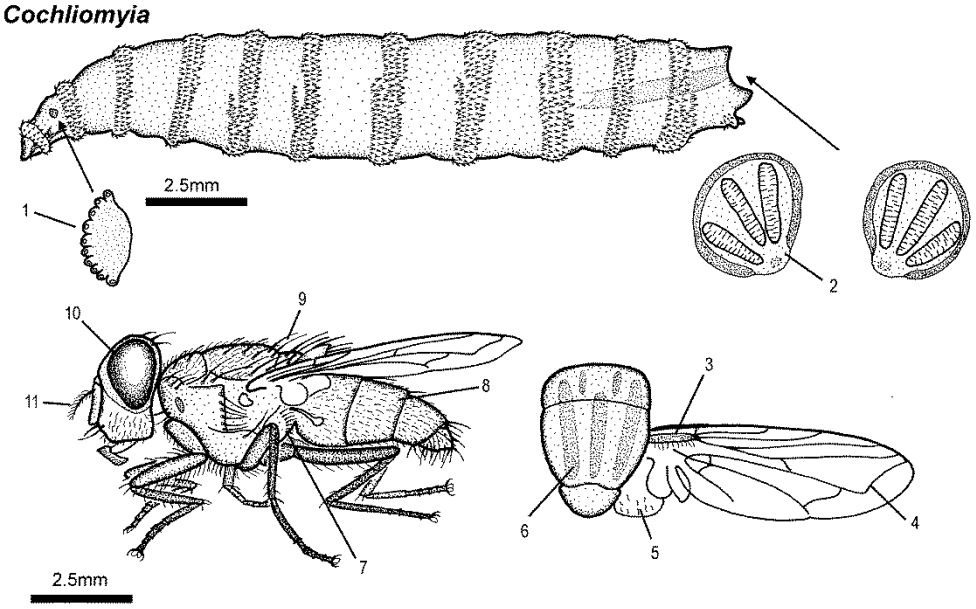
Hosts: *Chrysomya bezziana*, *C. megacephala* (Screw-worm flies) and other species are obligate parasites in their larval stage on cattle and other livestock species, and wild bovids.

Signs: The larvae are described as screw-worms because they burrow head first into the skin of their host, individually resembling screws for wood-work. A batch of eggs laid by one female at a slight wound in the skin leads to a wide lesion packed with several hundred mature maggots. Intact moist skin at nostrils and elsewhere may also be invaded.

Disease: Cutaneous myiasis of the Screw-worm type causes much pain and distress and can be fatal if the infestation starts at a wound on the ear or navel and penetrates deeply.

Distribution: These are known as the Old-World Screw-worm flies, distributed in tropical and sub-tropical Africa and Asia.[4,5]

Cochliomyia (Calliphoridae, Screw-worm flies) [to Contents]

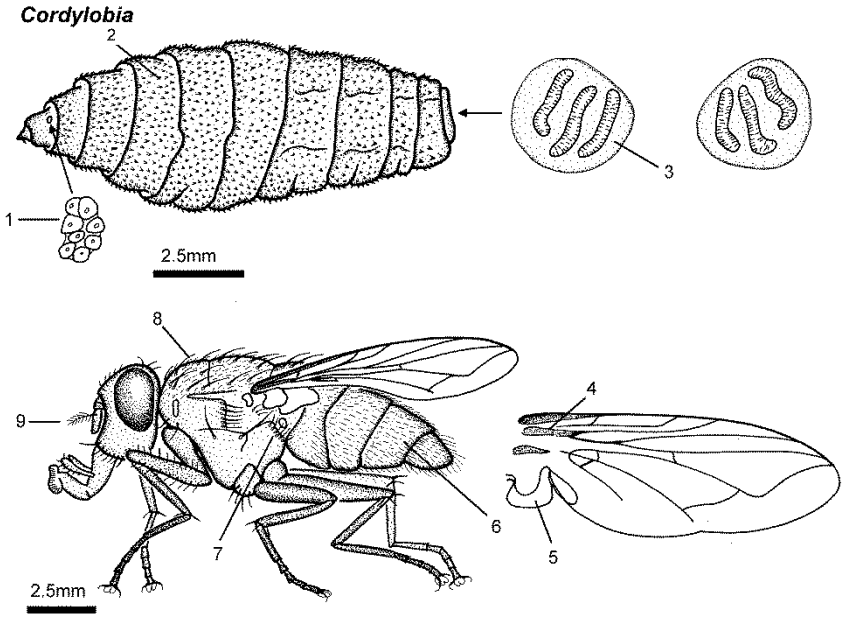


Characters: larva, adult, lateral. 1- Anterior spiracles have 7 to 10 openings. 2- Posterior spiracles have a peritreme that is incomplete. 3- Stem vein of wing has a row of setae. 4- Vein 4 of wing is angled sharply up toward the outermost edge. 5- Thoracic squama has setae on its upper surface. 6- Dorsal surface of thorax has distinct dark stripes. 7- Hypopleuron of thorax has a row of stout setae. 8- Thorax and abdomen are metallic blue/green. 9- Setae on top of thorax are relatively dense and long. 10- Eyes are red/brown or orange. 11- Antenna has arista with setae on both sides.

Hosts: *Cochliomyia hominivorax* and *C. macellaria* (Screw-worm flies) are obligate parasites in their larval stage on cattle and other livestock species, horses, also rarely humans (after whom *C. hominivorax* was named).
Signs and symptoms: As for *Chrysomya*; these Screw-worms create a wide lesion when many of them from one batch of eggs burrow directly into the skin.
Disease: Cutaneous myiasis of the Screw-worm type causes much pain, distress, loss of production, and can be fatal if the infestation starts at a wound on the ear or navel and then penetrates deeply.
Distribution: These ectoparasites are known as the New-World Screw-worm flies, distributed widely in tropical and sub-tropical areas of the Americas. (Note that *Chrysomya* and *Cochliomyia* are closely similar, but *Cochliomyia* are restricted to the Americas. There was an accidental introduction on transported livestock of *C. hominivorax* into Libya, but it was eradicated there before it could spread further. Also *C. hominivorax* has been eradicated from the USA, Mexico and other Central American countries using sterile insect technique (see Wikipedia articles).[6,7]

Cordylobia (Calliphoridae, Blow-flies)

[to Contents]



Characters: larva, adult, lateral. 1- Anterior spiracles are in form of an irregular clump of openings. 2- Larvae are stout and covered in small sharp spines. 3- Posterior spiracles are on a circular plate and the openings are variously wavy in outline. 4- Stem vein of wing is without setae. 5- Thoracic squama of wing is without setae. 6- Abdomen and thorax are dull yellow/brown; adults are large. 7- Hypopleural setae of the thorax are distinct. 8- Thorax dorsal surface bears a small number of large bristle-like setae and numerous small setae. 9- Antenna has an arista with setae on both sides.

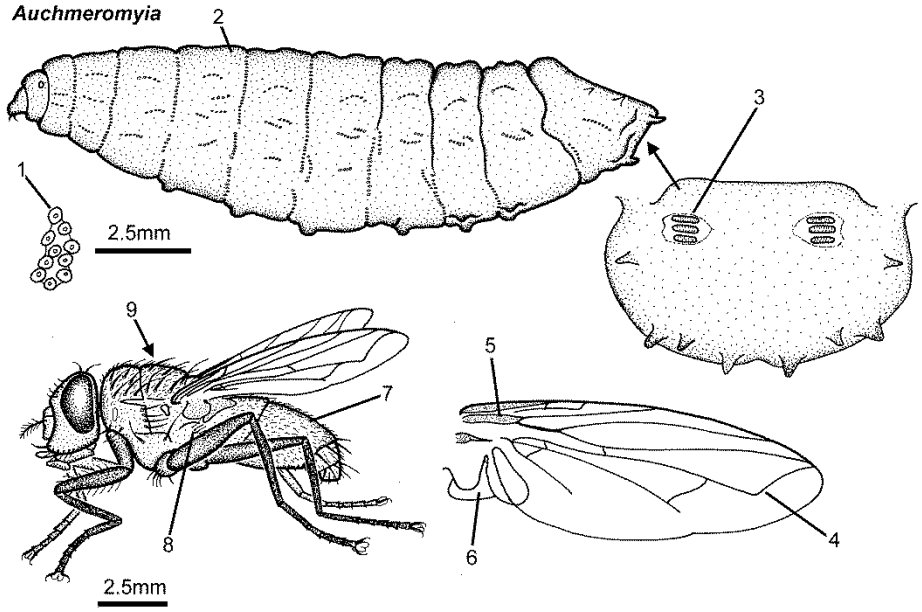
Hosts: Dogs, cats, humans, rodents and wild bovids are used as hosts for the larvae.

Signs, symptoms and disease: Furuncular myiasis of the skin causes pain, distress and malaise. *Cordylobia* species are exceptional amongst myiasis causing flies: the females lay eggs on soil or in nest of their hosts, this is nidicolous behavior. They also will lay eggs on clothing hung out to dry. Thus adult flies are rarely associated with the diseased hosts. Larvae emerging from eggs then independently seek their host to invade them through their skin.

Distribution: *Cordylobia* inhabits Africa south of the Sahara. Note that humans who suffered infestation in Africa by larvae of Tumbu-fly, or Lund's-fly (both *Cordylobia* species) may present their myiasis problem in other parts of the world after travelling.[8]

Auchmeromyia (Calliphoridae, Blow-flies)

[to Contents]



Characters: larva, adult, lateral. 1- Anterior spiracles of larva have a bunch of openings. 2- Larvae are dark brown, without spines, but with tubercles. 3- Posterior spiracles have 3 straight and horizontal openings; the peritremes are indistinct. 4- Vein 4 of wing bends up toward leading edge. 5- Stem vein of wing has no bristles. 6- Thoracic squamae have no setae. 7- Second abdominal segment of female is longer than first or third segments. 8- Hypopleural bristles are present. 9- Color of adults is dull yellow/brown or red/brown.

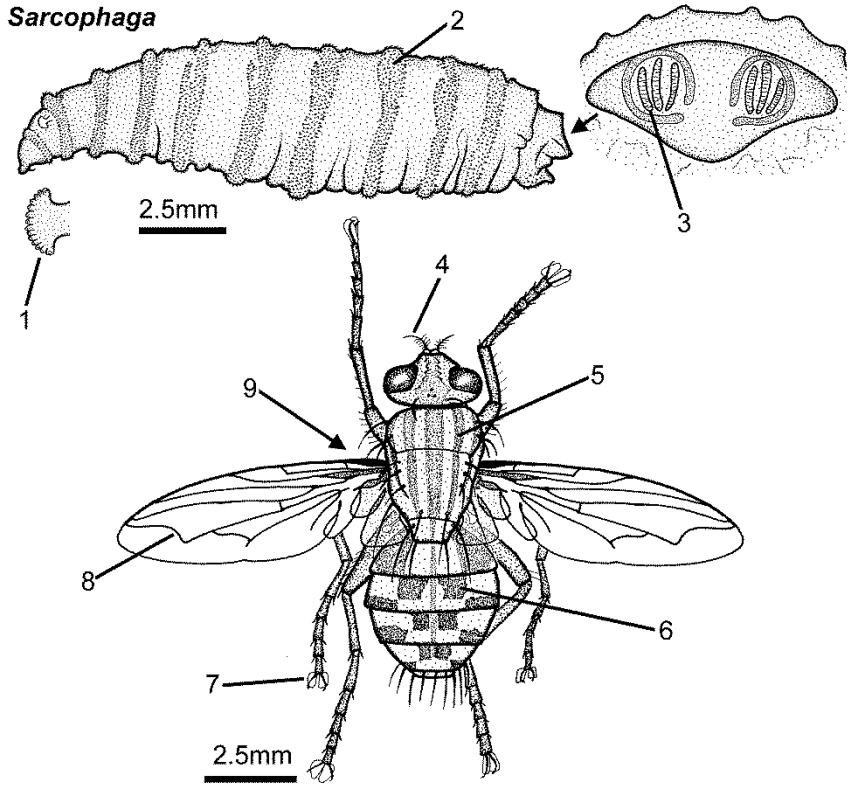
Hosts: Wild pigs, warthogs, other large burrowing animals are the usual hosts, but also rarely humans may be parasitized.

Disease and distribution: *Auchmeromyia senegalensis*, the Congo Floor-maggot is the important representative of this genus. The genus is characterized by its larvae being adapted for blood feeding on their hosts whilst remaining free-living within the host's burrow. This can be described as an unusual form of myiasis.[9]

[Continued]

Sarcophaga (Sarcophagidae, Blow-flies)

[to Contents]



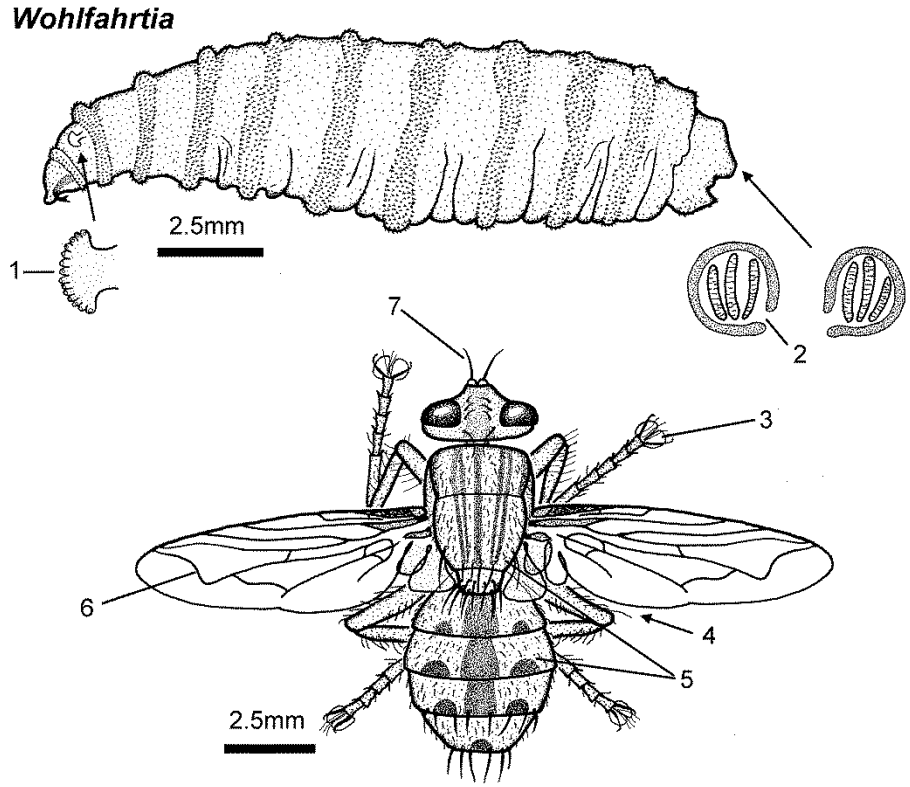
Characters: larva, adult dorsal. 1- Anterior spiracles have numerous openings. 2- Larval segments have bands of small spines. 3- Posterior spiracles each have 3 straight vertical openings and an incomplete peritreme. 4- Arista of antenna has setae at base but is plain anteriorly. 5- Thorax has 3 dark longitudinal stripes. 6- Abdomen has pattern of dark rectangles. 7- Vein 4 of wing bends towards the leading edge. 8- Legs end in large pulvilli and paired claws. 9- Hypopleural bristles are present on side of thorax.

Hosts: Usually species of *Sarcophaga* are entirely free living, similar to typical blow-flies. *Sarcophaga haemorrhoidalis* is usually a typical carrion fly, but sometimes it feeds as a facultative parasite of cattle, sheep and humans.

Signs and disease: The larvae may cause superficial myiasis, and also contaminative transmission of bacteria from carrion to domestic animals and humans.

Wohlfahrtia (Sarcophagidae, Flesh-flies)

[to Contents]



Characters: larva, adult dorsal. 1- Anterior spiracles have up to 14 openings. 2- Posterior spiracles have in incomplete peritreme and the openings of the spiracles are approximately parallel to each other. 3- Legs are long; they end in pairs of large pulvilli. 4- Thorax bears a row of setae on its hypopleuron (see on *Calliphora*). 5- Thorax and abdomen are dull light grey with distinctive patterns of black stripes and spots. 6- Wing has vein 4 curving sharply up towards the outer leading edge. 7- Antenna has arista without any setae.

Hosts: Larvae infest sheep, goats, cattle, camels, horses, dogs and humans. Larvae of *Wohlfartia* species are obligate parasites.

Signs, symptoms and disease: Cutaneous myiasis is caused as larvae burrow into skin. Larvae of some species cause lesions packed with larvae similar to those of Screw-worm flies, others cause furuncular lesions in the skin, like abscesses or boils, with separate individual larvae. Pain and stress is severe, production losses can be significant, and hosts may be killed by the infestation. Infestations of humans are rare and consist of only a few larvae, but these tend to be at the nose, with serious consequences.[10]

References

1. Erzinçlioğlu, Z. (1996) *Blowflies*. Slough, England, The Richmond Publishing Company. ISBN 0-85546-303-1.
2. Heath, A.C.G., & Bishop, D.M. (1995) Flystrike in New Zealand. Surveillance (Wellington), 22:, 11-13.
3. Waterhouse, D. F. (1947) The relative importance of live sheep and of carrion as breeding grounds for the Australian sheep blowfly *Lucilia*

cuprina. Bulletin of the Council for Scientific and Industrial Research, Australia, No.217 pgs 1-37.
4. Sutherst, R. W., et al. (1989) The potential geographical distribution of the Old World screw-worm fly, *Chrysomya bezziana*. Medical and Veterinary Entomology, 3: 273-280.
5. Wells, J. D. (1991) *Chrysomya megacephala* (Diptera: Calliphoridae) has reached the continental United States: review of its biology, pest status, and spread around the world. Journal of Medical Entomology, 28: 471-473.
6. Bush, G. L., & Neck, R. W. (1976) Ecological genetics of the screwworm fly, *Cochliomyia hominivorax* (Diptera: Calliphoridae) and its bearing on the quality control of mass-reared insects. Environmental Entomology, 5: 821-826.
7. Anonymous (1992) *The New World Screwworm Eradication Programme: North Africa, 1988-1992*. Rome, Food and Agriculture Organization of the United Nations.
8. Tamir, J., et al. (2003) Myiasis with Lund's fly (*Cordylobia rodhaini*) in travelers. Journal of Travel Medicine, 10: 293-295.
9. Lane, R.P., et al. (1987) Human cutaneous myiasis - a review and report of three cases due to *Dermatobia hominis*. Clinical and Experimental Dermatology, 12: 40-45.
10. Farkas, R., et al. (2009) Traumatic myiasis in dogs caused by *Wohlfahrtia magnifica* and its importance in the epidemiology of wohlfahrtiosis of livestock. Medical and Veterinary Entomology, 23: 80-85.

Bot-flies and Warble-flies (Diptera, Oestridae)

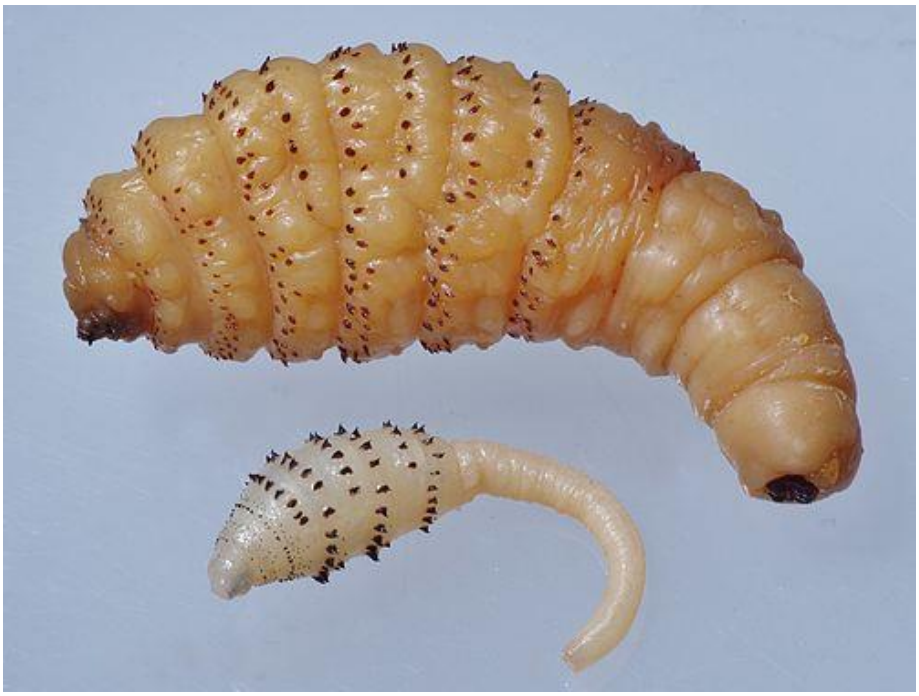
Characters of oestrid flies

[to Contents]

All flies in the Oestridae are highly specialized for parasitism so that the entire feeding to maintain the life-cycle is done by the larvae. This specialized life-cycle defines these insects as obligate parasites. The adults have only vestigial mouthparts remaining from this adaptation, so they cannot feed. Larvae become distended with food reserves to support the adult stage with all materials and energy reserves for reproduction.

Adult flies are robust and actively fly long distances in search of mates and hosts for their larvae. It may be difficult to find these adults and identification focusses on characters of the larvae. Adults have a distinctly characteristic appearance, like that of Bumble-bees: furry and with colored stripes. Host animals can often recognize and flee from the approach of adult flies.The posterior spiracles of larvae have highly characteristic patterns, but the anterior spiracles are absent or obscure. The posterior spiracles of oestrid larvae form a pair of large flat plates with numerous

small openings. This contrasts with posterior spiracles of calliphorid larvae which are usually a trio of slits surrounded by a peritreme (see Blow-flies).



Photograph shows a mature and an immature larva of the Torsalo Bot-fly, *Dermatobia hominis*, parasite of cattle and humans, causing furuncular myiasis.

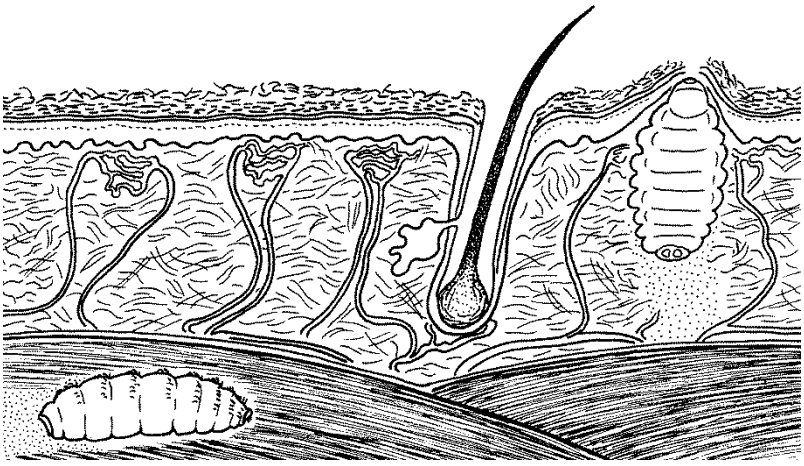


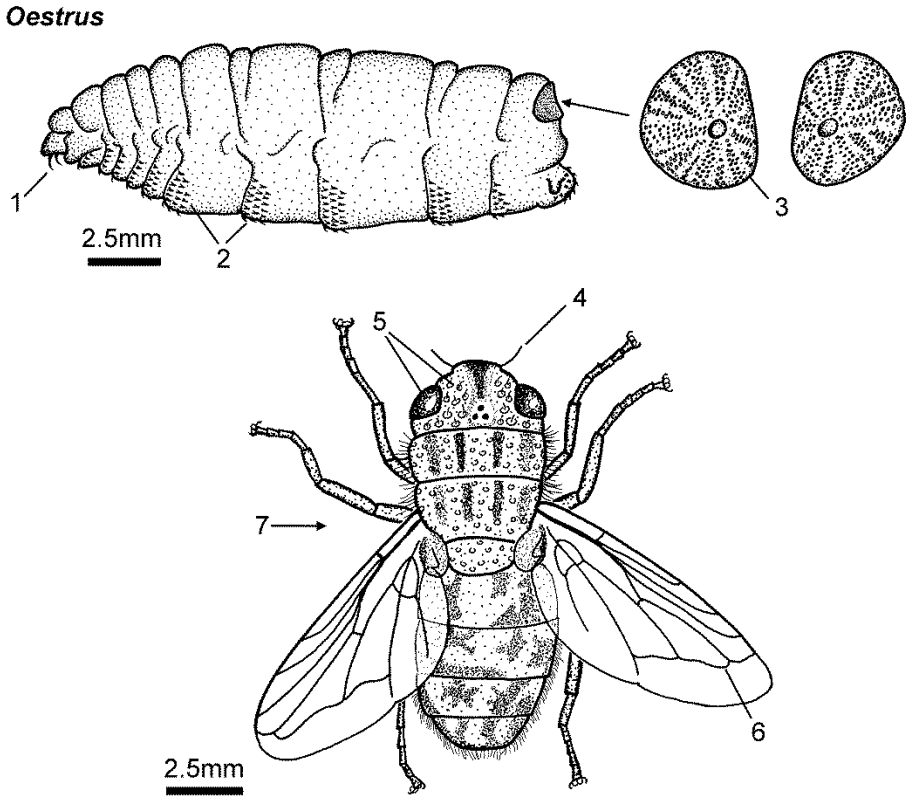
Diagram of feeding in skin represents *Hypoderma* Warble-fly larvae, causing migratory myiasis. Larvae burrow within the skin and sub-cutaneous tissue of its host (scales are not accurate). Larva at left is migrating through sub-cutaneous tissues. Larva at right is preparing to mature under surface of skin, forming a warble. This maturing larva has not yet turned into its final position so that its spiracles face to external air through a hole that it will cut through the skin.

Glossary

- Avoidance behavior = Some animals that are natural hosts of oestrid flies recognise the approach of adult females and will run away in panic to avoid the flies.
- Furuncle = An abscess or boil in the skin of a host caused by infestation with an individual myiasis larva.
- Gadding = A veterinary / farming term for avoidance behavior.
- Obligate myiasis = Infestation of skin and other organs by dipteran larvae where the parasitism is essential to survival and reproduction of the flies.
- Phoresy = Use of another animal by a reproducing animal to disperse its eggs or offspring.
- Spine = A projection of the body wall to form a sharp gripping structure (2 on *Gasterophilus*).
- Tubercle = a rounded protrusion of the body wall (4 on *Rhinoestrus*).
- Vestigial mouthparts = Adult oestrid flies gain all nutrients from their larvae – only traces of their mouthparts remain (6 on *Rhinoestrus*).
- Warble = Vernacular term for a furuncle caused by a single oestrid larva in the skin.

Oestrus (Oestridae, Bot-flies)

[to Contents]



Characters: larva, adult dorsal. 1- Prominent rasping mouthparts. 2- Larva has rows of small spines on bands at ventral surface of each segment; dorsally mature larvae have dark bands on each segment; fleshy projections are absent. 3- Posterior spiracles are on a nearly circular plate, without indentation, and with many openings in pattern of rays. 4- Antenna has large arista without setae. 5- Head

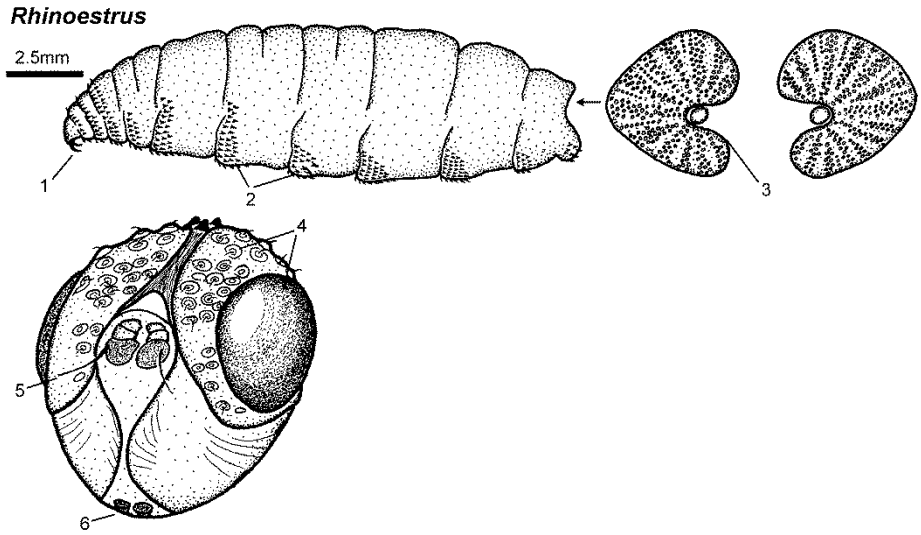
bears numerous small tubercles; eyes are small relative to head, and with a large gap between them. 6- Wings are clear; vein 4 of the wing joins vein 3, it does not reach the wing margin directly. 7- Adults have thorax and abdomens with mottled patterns of black on grey; mouthparts are vestigial.

Hosts: *Oestrus ovis* (Nasal bot-fly of sheep) larvae infest the nasal cavities of sheep and goats.

Signs and disease: Infestation causes irritation, head-shaking, sneezing, nasal discharge, distress and avoidance behavior. Apart from the danger of a heavy infestation of larvae in the head, the behavior of tightly packed defensive flocking (Fly-syndrome) reduces productivity.[1]

Rhinoestrus (Oestridae)

[to Contents]



Characters: larva, head of adult. 1- Prominent rasping mouthparts. 2- Larva has rows of small spines on bands at ventral surface of each segment. 3- Posterior spiracles on oval plate that has a deep indentation, and with many openings in pattern of rays. 4- Head bears numerous large tubercles. Eyes are small relative to head, and with a large gap between them. 5- Antenna has a large arista without any setae. 6- Mouthparts are vestigial.

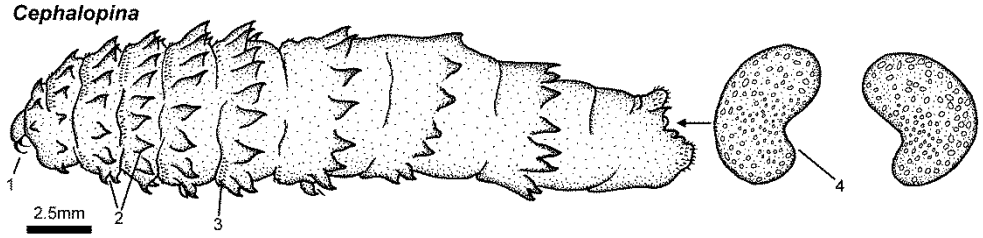
Hosts: *Rhinoestrus purpureus* (Nasal bot-fly of horses) infests the nasal cavities of horses and donkeys.

Signs and disease. Irritation, head-shaking, sneezing, nasal discharge, and lack of coordination are caused.

Distribution. Flies of this genus inhabit Eastern Europe and Russia.

Cephalopina (Oestridae, Bot-flies)

[to Contents]



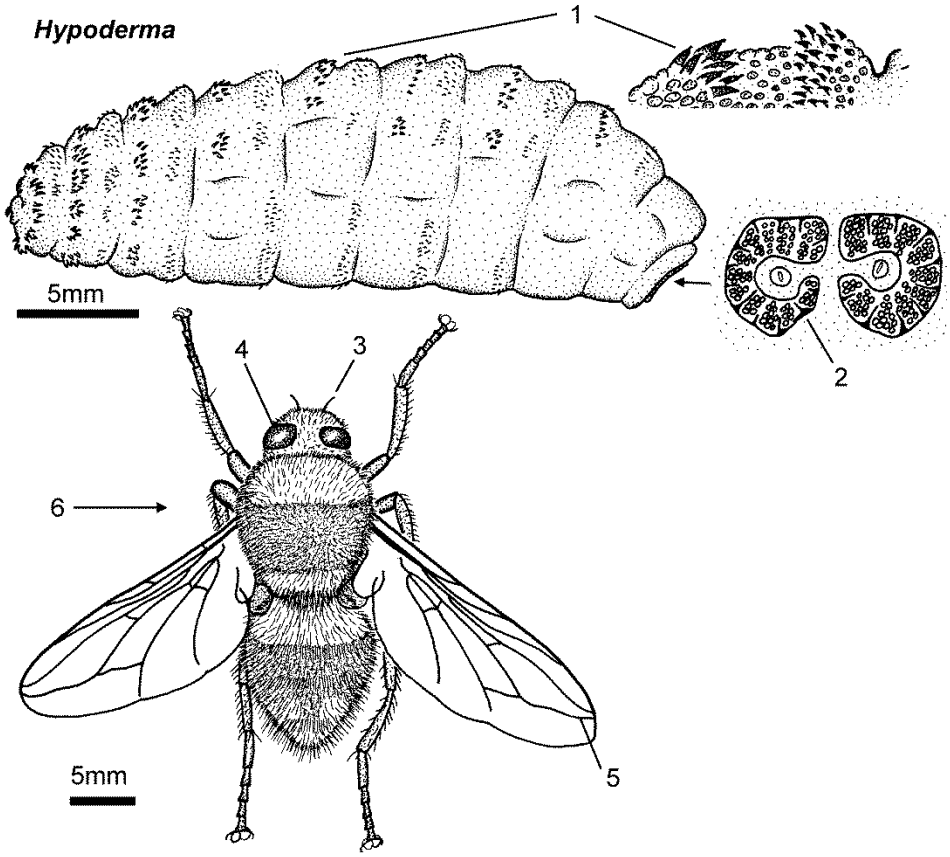
Characters: larva. 1- Large rasping mouthparts. 2- Segments 2 to 9 bear large stiff fleshy projections. 3- Anterior segments also have bands of small spines. 4- Spiracles are on an oval plate with a broad indentation; openings form a scattered pattern.

Hosts: *Cephalopina titillator* (Nasal bot-fly of camels) infests the nasal cavities of dromedary camels and bactrian camels.
Signs and disease: Irritation, snorting and sneezing, bleeding from nostrils, lack of coordination: these all lead to reduced production of milk, and reduced gain of body weight.
Distribution: Dry regions of Sub-Saharan Africa and Asia are inhabited, also Australia where introduced dromedary camels may be infested.

[Continued]

Hypoderma (Oestridae, Warble-flies)

[to Contents]



Characters: larva, adult dorsal. 1- Larva has paired of bands of spines on dorsal surface; the spines here have points facing each other; there are no fleshy projections from the surface of the larva. 2- Posterior spiracles form open rings, with groups of openings arranged around each ring. 3- Antenna has large arista without setae. 4- Eyes are small relative to head, and with a large gap between them. 5- Wings are clear; vein 4 of the wing reaches directly to the leading edge of the wing. 6- Adults are large; thorax and abdomens have a dense covering of fine setae in bands of brown and yellow; mouthparts are vestigial.

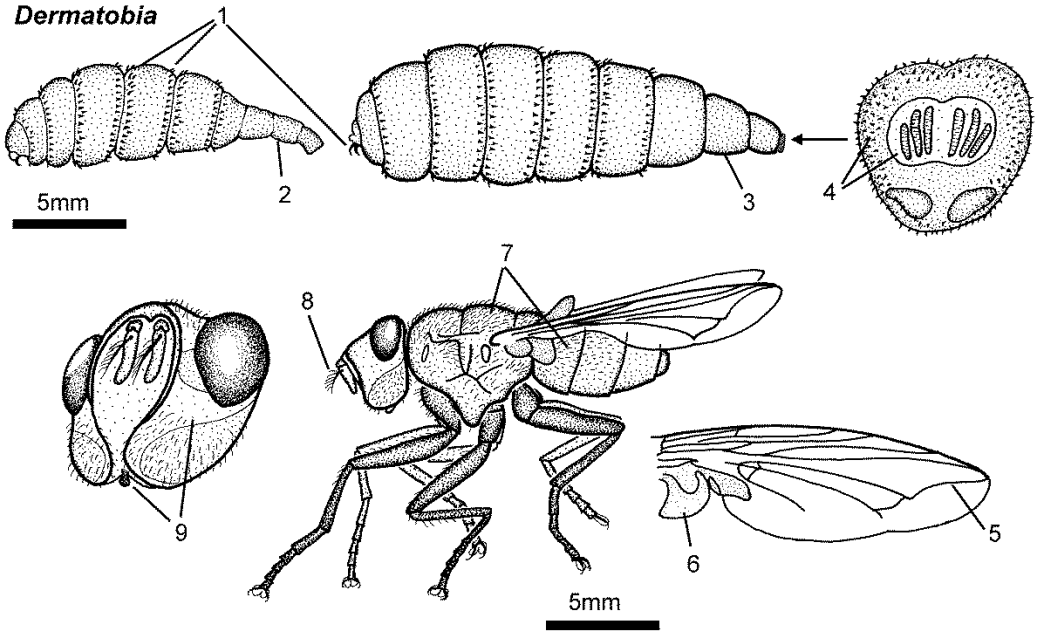
Hosts: Cattle are infested by *Hypoderma bovis* and *H. lineatum* (Warble-flies or Gad-flies). *Hypoderma diana* infests deer but may also infest sheep, although without being able to complete its larval development there. Similarly humans may become infested, but only rarely.

Signs: Larvae hatch from eggs laid by the female directly on leg hairs of hosts. Hatched larvae immediately burrow beneath host's skin and migrate through connective tissues and muscle to appear one year later as mature larvae along the back. As the larva matures it forms a distinct furuncle in the skin; this is the warble.[2]

Disease: Migratory myiasis followed by furuncular myiasis reduces the value of meat and hides. Avoidance behavior of cattle as they panic to escape when approached by female flies, leads to stress and injury from collisions (this behavior is often called gadding).

Dermatobia (Oestridae, Warble-flies)

[to Contents]



Characters: larva, adult dorsal and lateral. 1- Larvae have 2 rings of backward facing spines on the anterior segments; rasping mouthparts are large. 2- Larva at second stage of development has posterior segments elongated and narrow. 3- Larva at third stage of development has posterior segments thick and not elongated. 4- Terminal segment of stage 3 larva is sclerotized and spiny; its spiracles have 3 openings parallel to each other and they are not surrounded by a distinct peritreme. 5- Vein 4 of wing reaches directly the outermost point of the wing. 5- Thoracic squama is large and without setae. 7- Adults are large, with a yellow/brown thorax and metallic blue abdomen; eyes are orange and side of face is white. 8- Antenna has an arista with setae on one side. 9- Side of the head is broad; mouthparts are vestigial.

Hosts: Cattle, sheep, dogs, birds and occasionally humans are infested by *Dermatobia hominis* (the Torsalo-fly, Human bot-fly, Berne, Nuche, and other local names).[3]

Signs and disease. Furuncular myiasis of the skin is highly characteristic. Pain and severe distress leads to reduced feeding time, loss of production and damage to hides.

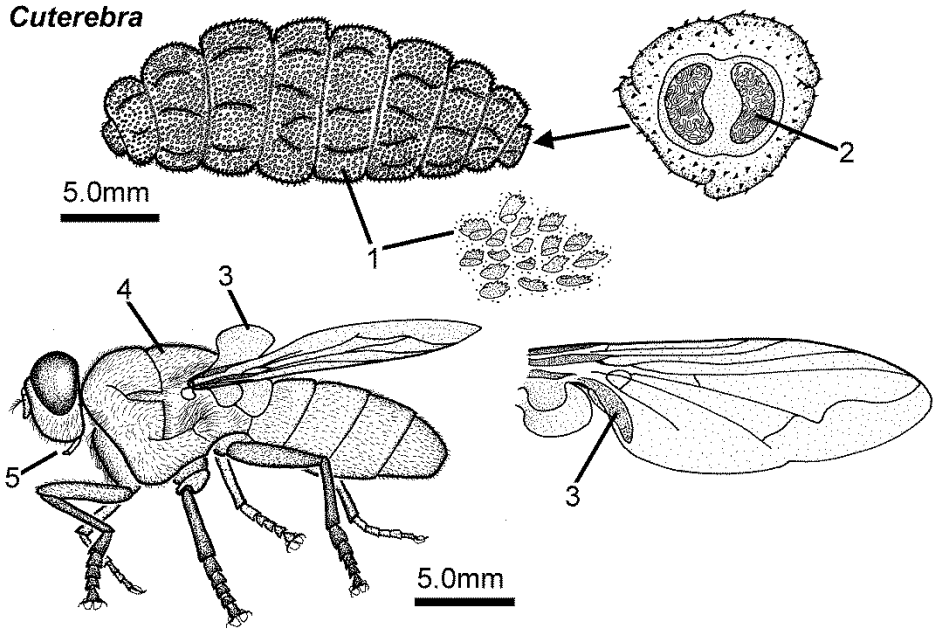
Distribution: These flies inhabit Central and South America, from Mexico to Uruguay.

Note: Of this genus the important species, *D. hominis*, has a specialized method of getting its eggs onto its mammal host. The female lays small batches of eggs on a blood-sucking insect. When that insect lands on its host to feed, the additional warmth stimulates the larvae of *D. hominis* to emerge then rapidly burrow into the mammal's skin. This is an example of phoresy. Individual larvae continue to develop at that site, forming large furuncles.

The furuncles tend to be grouped together where the original carrier insect fed on blood of host. Furuncles become large and suppurating as the larvae develop. The mature larva emerges, drops to the ground and pupates.

Cuterebra (Oestridae, Warble-flies)

[to Contents]



Characters: larva, adult lateral. 1- Fully mature larvae are stout and covered in scale-like spines. 2- Posterior spiracles of larvae are kidney shaped and with many fine, curved openings. 3- Alula of the wing is conspicuously large. 4- Abdomen and thorax is densely covered with short setae. 5- Mouthparts are residual.

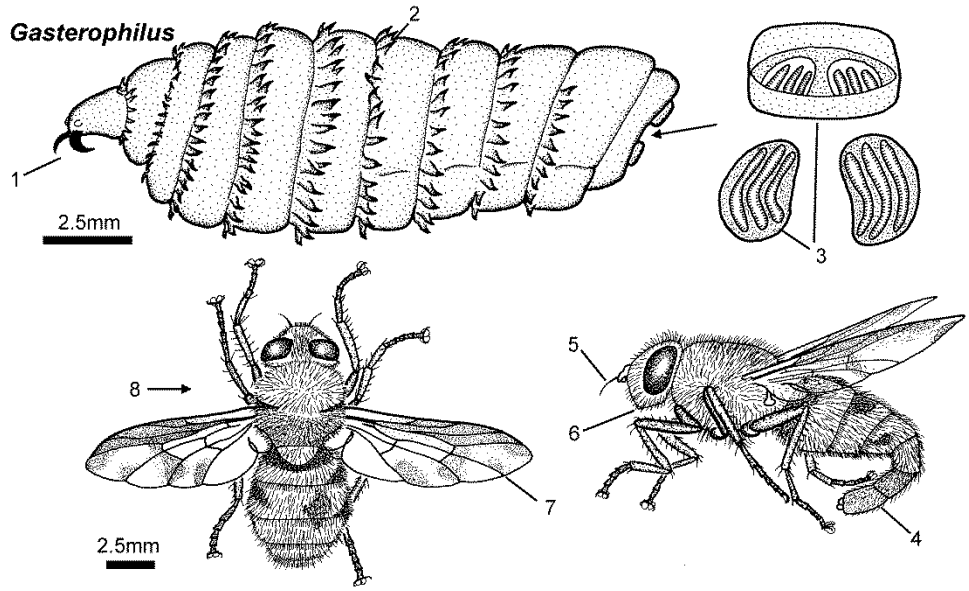
Hosts: Principally rodents and rabbits are infested, but cats and dogs are sometimes infested.

Signs and disease. Furuncular myiasis of the skin is caused. The female fly lays eggs at nests of its hosts. Larvae then penetrate the host's skin and develop beneath the skin, forming large nodules. Larvae infesting cats occasionally penetrate the brain with serious consequences.

Distribution: Warm climates of South and North America.

Gasterophilus (Oestridae, Stomach bots)

[to Contents]



Characters: larva, adult dorsal and lateral. 1- Large rasping mouthparts are prominent. 2- Larva has bands of large backward pointing spines around the full circumference of most segments; there are no fleshy projections. 3- Posterior spiracles form oval plates, with 3 elongated curved openings on each plate; spiracles are within a deep depression in the last segment (anterior spiracles usually visible as small bunches of protruding tissue). 4- Abdomen of female is long and extends in a fold underneath the main body. 5- Antenna has large arista without setae. 6- Mouthparts are vestigial. 7- Wings have dark patches; vein 4 of the wing reaches directly to the trailing edge of the wing. 8- Thorax and abdomen are covered with a dense covering of fine setae which are dark brown or yellow in a patchy pattern; eyes are dark brown.

Hosts: Horses and other equids including zebras, also elephants and rhinoceroses.[4]

Signs and disease: Vigorous avoidance behavior occurs when adult flies chase their hosts. Initial infestation causes stomatitis and ulceration of the tongue; loss of appetite and even threat to life from inflammatory restriction of host's esophagus. However, larvae maturing in the stomach seem to cause little ill health, despite infestations here sometimes being heavy.

Note: The adult female fly lays eggs on the legs of her host. When the larvae hatch they crawl on the skin, stimulating the host to groom by licking. The larvae then establish their infestation in the mouth of the host, followed by migration to the stomach.

References

1. Yilma, J.M.; & Dorchies, P. (1991) Epidemiology of *Oestrus ovis* in southwest France. Veterinary Parasitology, 40: 315-323.
2. Otranto, D. (2001) The immunology of myiasis: parasite survival and host defense strategies. Trends in Parasitology, 17: 176-182.

3. Jelinek, T., et al. (1995) Cutaneous myiasis: review of 13 cases in travelers returning from tropical countries. International Journal of Dermatology, 34: 624-626.
4. Edwards, G.T. (1982) The prevalence of *Gasterophilus intestinalis* in horses in northern England and Wales. Veterinary Parasitology, 11: 215-222.

Louse-flies and Keds (Diptera, Hippoboscidae)

Characters of hippoboscid flies

[to Contents]

These flies can be mistaken for large lice or ticks because of their sedentary feeding habits on their hosts. This is particularly the case for the Sheep-ked (*Melophagus ovinus*) which never develops wings, and *Lipoptena* species (Deer-keds) which shed their wings as soon as they have found a host after emergence from the puparium. Reproduction by hippoboscids is by larvipary. One egg at time develops into a larva within the female's oviduct. It develops fully and pupates as soon as it emerges from the female.

Photograph shows *Melophagus ovinus* adult Sheep-keds (male left, female center, and a puparium at right). These wingless flies remain permanently ectoparasitic on their hosts and the female glues each puparium it lays onto the hair of the sheep.

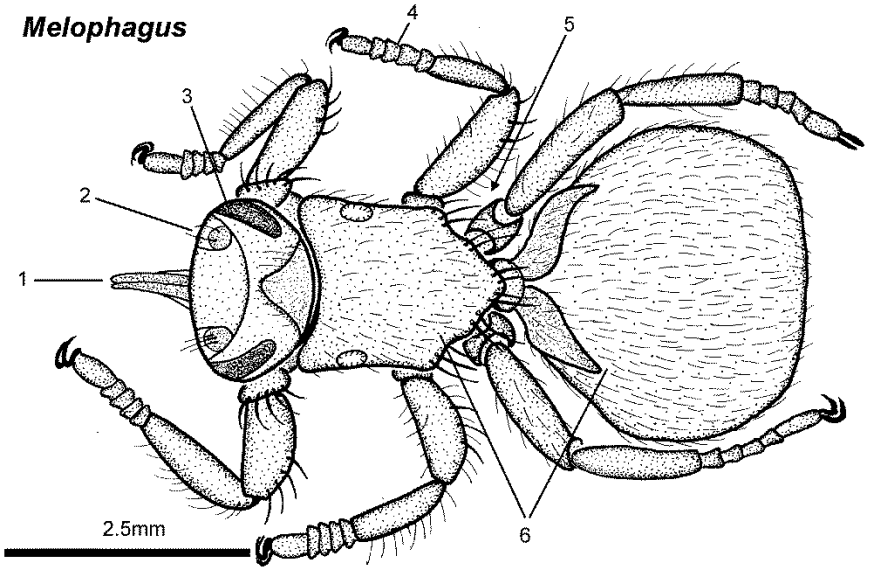
These flies have piercing mouthparts to feed on blood; the long thin mouthparts are retracted into head when not in use. *Hippobosca* species fly actively from host to host. *Melophagus ovinus* is resident on its sheep host for its complete life-cycle. Despite the active feeding by both sexes these flies are mostly important for biting-stress, not transmission of other pathogenic parasites.

Glossary

- Ked = Vernacular term for *Melophagus ovinus*, the hippoboscid fly that infests sheep.
- Larvipary = Reproduction in which an egg develops in the female to form a single larva which then develops fully within the female, the mature larva is then laid and rapidly forms a puparium inside which it develops into a pupa. Compare with larvipary by Tsetse-flies (see Houseflies and similar).
- Palp = A pair of sensory organs associated with the mouthparts. On hippoboscid flies the piercing mouthparts are retracted within the head when not in use.
- Puparium = A case that is formed from the body wall of mature larvae of some dipteran flies; inside this case the larva changes into the pupal stage of complete metamorphosis.

Melophagus (Hippoboscidae, Sheep ked)

[to Contents]



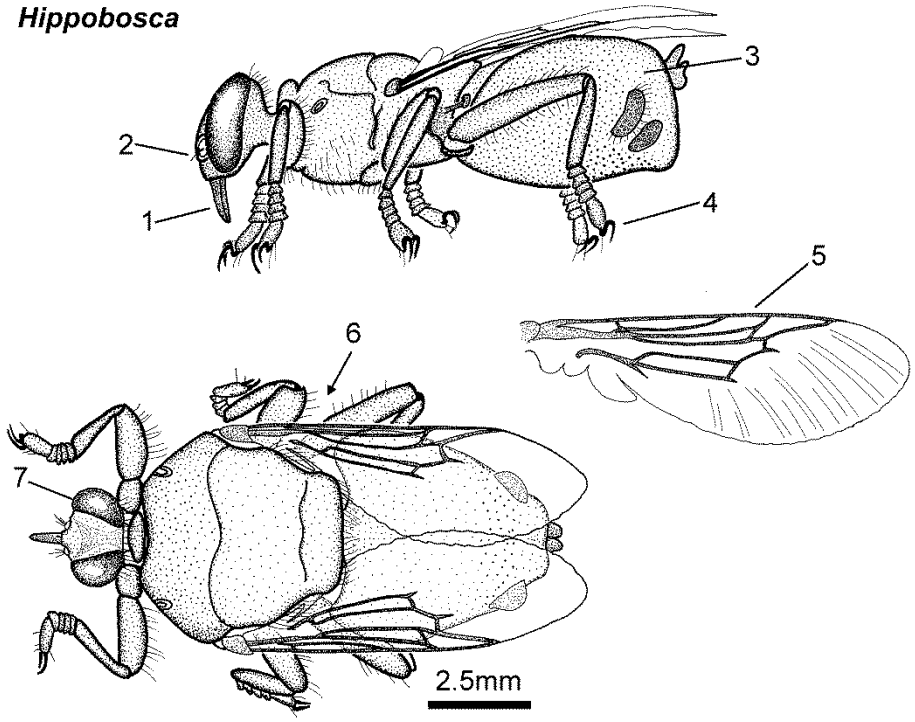
Characters: adult, dorsal. 1- Palps are prominent below the head. 2- Antennae are compacted into pockets in the head, and a few long setae protrude from them. 3- Eyes are relatively small, and brown. 4- Legs are long and stout and equipped with a pair of large claws. 5- Wings never develop. 6- Segmentation is not evident on thorax and abdomen; body is grey and brown and bears many setae.

Hosts: *Melophagus ovinus* infests sheep.

Signs and disease: Sheep-keds cause irritation, pruritus, biting-stress, soiling of wool with ked feces and depilation. Allergic dermatitis develops at the feeding sites causing the damage to prepared hides called cockle.[1]

Hippobosca (Hippoboscidae, Louse-flies)

[to Contents]



Characters: adult, lateral and dorsal. 1- Palps protrude prominently below head. 2- Antennae are compacted into pockets in the head and have a few long setae protruding. 3- Abdomen is either flattened dorso-ventrally or is stout (as shown) because it contains a developing larva; segmentation of the abdomen is not clear. 4- Legs are long and stout; they end in a pair of large claws. 5- Wings are well developed with thick veins toward the leading edge and no veins toward the trailing edge. 6- These are large, robust, shiny brown flies. 7- Eyes are large, widely separated, and brown.

Hosts: *Hippobosca rufipes* and *H. variegata* (Cattle louse-fly) feed on cattle and horses. Similarly: *H. camelina* (Camel louse-fly) on camels; *H. equina* (Horse louse-fly) on horses; *H. longipennis* on dogs.[2]

Signs: *Hippobosca* species of Louse-flies move rapidly from one animal to another within a herd of livestock by flying. These flies take repeated small meals of blood. Also they will spend much time clinging to hair coat of their host.

Disease: Irritation and biting-stress are caused.

Distribution: *Hippobosca* flies inhabit Europe, Africa, Middle East, Central and South East Asia.

References

1. Small, R. W. (2005) A review of *Melophagus ovinus* (L.), the sheep ked. Veterinary Parasitology, 130: 141-155.
2. Hafez, M., & Hilali, M. (1978) Biology of *Hippobosca longipennis* (Fabricus, 1805) in Egypt (Dipteria: Hippoboscidae). Veterinary Parasitology, 4: 275-288.

Assassin-bugs or Conenose-bugs, and Bed-bugs (Hemiptera, Reduviidae)

Characters of reduviid blood-sucking bugs

[to Contents]

The term bug is used by entomologists in a formal sense for this group of insects. This term derives from ancient familiarity with Bed-bugs, which are insects highly adapted to parasitize humans. Both Assassin-bugs and Bed-bugs are nidicolous, adapted to living in nest or housing of their host. They feed at night, crawling from their hiding places in the housing of their hosts. The bugs feed fully on their hosts then return to their resting sites within the house or nest. This is especially important for the medical aspects of these blood-suckers that are adapted to go through their entire life-cycle within the structures of poor quality housing.

Photograph above shows an Assassin-bug of the genus *Triatoma*, with its two pairs of wings folded over a wide, flat, abdomen; and its elongated head and antennae.

Both sexes feed on blood and are similar in appearance. The proboscis (or rostrum) of hemipteran bugs is long and slender; it folds away under the head when not in use. The size of the blood meals is large relative to the size of the bugs. All hemipteran bugs have an incomplete metamorphosis, with five nymph stages. Nymphs have no wings, these are gained with the final molt into an adult. Adult Assassin-bugs have two pairs of wings. When not in use the wings are folded down closely to the dorsal surface of the abdomen. The Bed-bugs are without wings at all stages.

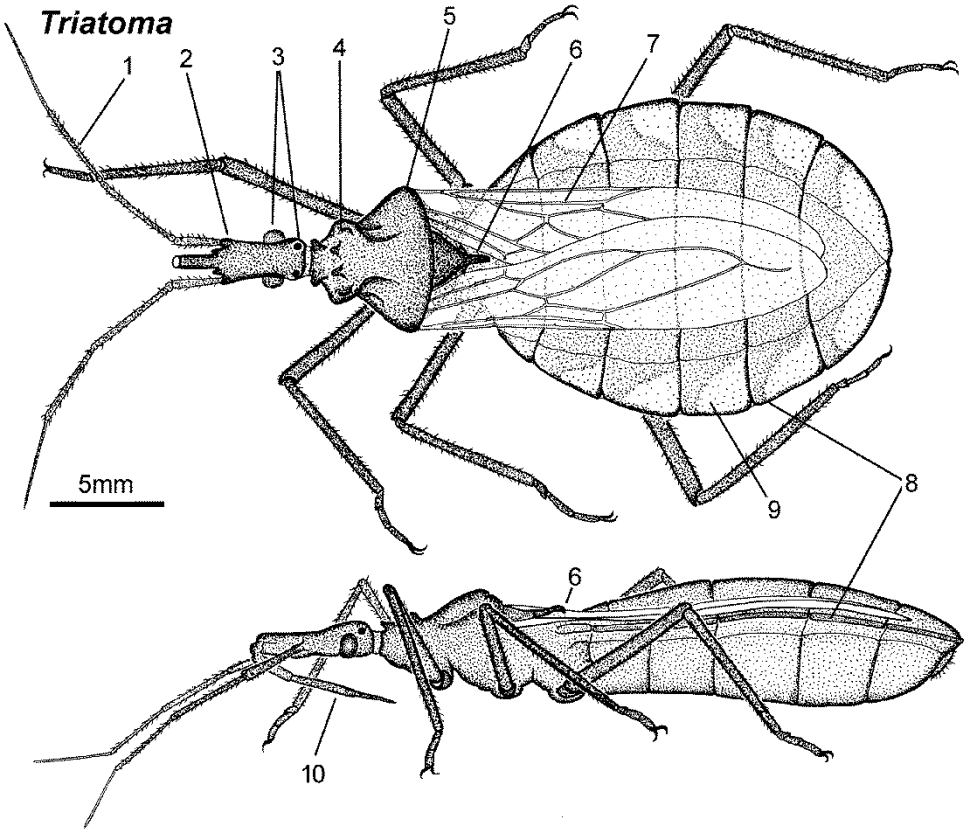
There are many genera and species of Assassin-bugs in the sub-family Triatominae; the genera most important to health are *Triatoma*, *Rhodnius*, and *Panstrongylus*. One example genus is provided here.[1]

Glossary

- Bug = Formal name for insects within the family Reduviidae, as in Bed-bug.
- Integument = The outer body wall of insects and acarines, which also acts as their external skeleton.
- Nidicolous = In this context, the behaviour of insects or acarines that inhabit the nests of their hosts.
- Ocelli = A type of simple eye with a single sensory unit, in contrast to compound eyes with many sensory units.
- Proboscis = A term (also known as rostrum) used to describe mouthparts of insects adapted for piercing or probing to feed.

Triatoma (Reduviidae, Assassin-bugs)

[to Contents]

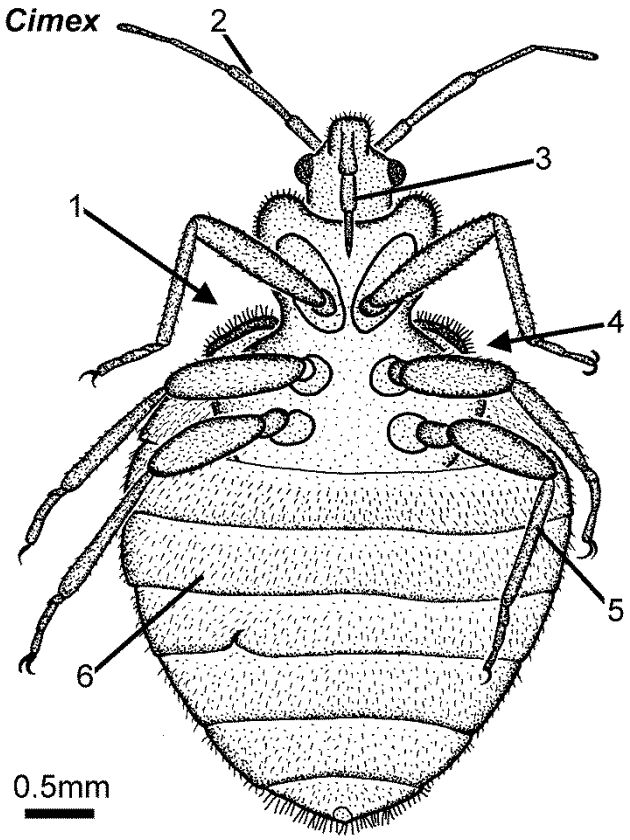


Characters: adult, dorsal and lateral. 1- Antennae consist of 4 elongated thin segments. 2- Base of antenna is at a position midway between eyes and anterior margin of the head. 3- At the base of the head is a pair of small eyes and a pair of large ocelli. 4- Thorax has a rough texture with large tubercles; it is dark brown. 5- Pronotum of the thorax is wide. 6- Scutellum of the thorax is elongated and turned down at its posterior margin. 7- Two pairs of wings are borne on the thorax; the fore-wings have thick veins; wings at rest are folded closely over the abdomen. 8- Abdomen is wide, with a distinct rim, and in unfed bugs is flattened. 9- Abdomen has varied patterns of brown on a yellow or orange background. 10- Proboscis is very long; when not in use it is folded beneath the head.

Hosts: A wide variety of animals are used for temporary blood-feeding by *Triatoma*: dogs, cats, cattle, sheep, goats, poultry birds, and humans.
Signs and disease: The bites leads to irritation, wheals and erythematous papules at feeding sites. Feeding may be associated with transmission of the protozoan *Trypanosoma cruzi*, the causative organism of Chaga's disease of much importance to humans, and also causing similar disease in dogs. However, the transmission route is via the bug's feces containing *T. cruzi* which then contaminate the site of blood-feeding.[2]
Distribution: Most species of Assassin-bugs occur in tropical and sub-tropical regions of the Americas but some occur in South East Asia and Africa.

Cimex (Cimicidae, Bed-bugs)

[to Contents]



Characters. female, ventral. 1- Adults (and nymphs) have no wings. 2- Antennae are long, with 4 segments. 3- Proboscis is long and folds under head when no in use. 4- Body is flattened dorso-ventrally. 5- Legs are well developed, each ending in paired claws. 6- Integument is densely covered with short, stout, setae.

Hosts: Humans and chickens are the principal hosts. The Bed-bugs have adapted to be closely associated with the housing constructed by humans for themselves and their poultry birds. The bugs live in cracks and crevices in

both the structure of the buildings and also furniture and fittings such as mattresses.

Symptoms and disease: In contast to the Assassin-bugs, the Bed-bugs are not important as transmitters of pathogens to humans. Although the bites of Bed-bugs are often not felt by sleeping humans, the feeding site becomes inflamed, thickened and painful later on. Individual humans vary in their immune reactions to bites of Bed-bugs: some can become desensitized by repeated exposure whilst others become hypersensitized. Sometimes massive infestations build up in housing, leading to psychological distress and malaise of the inhabitants. The bugs secrete a pheromone (a chemical signal between them) which at high concentrations gives a characteristic smell perceptible to people.

Distribution: The species *Cimex hemipterus* is the Tropical Bed-bug; *Cimex lectularius* is the Common Bed-bug of temperate climates; *Leptocimex boueti* is a Bed-bug of importance in Africa.[3]

References

1. Schofield, C.J. (1994) *Triatominae: Biology and Control*. Bognor Regis, England, Eurocommunications Publications.
2. Dias, J.C.P. (2007) Southern Cone Initiative for the elimination of domestic populations of *Triatoma infestans* and the interruption of transfusion Chagas disease: historical aspects, present situation, and perspectives. Memorias do Instituto Oswaldo Cruz, 102: 11-18.
3. Wang, C.; Saltzmann, K.; et al. (2010) Characteristics of *Cimex lectularius* (Hemiptera: Cimicidae), infestation and dispersal in a high-rise apartment building. Journal of Economic Entomology, 103: 172-177.

Acarines (Acarina)

Characters of mites and ticks of veterinary importance

The Order Acarina contains many sub-Orders of mites, each of which has numerous Families. There is one sub-Order of ticks, with two Families. Most species of mites are free-living but all the ticks are obligate blood-sucking ectoparasites. The mites and ticks have closely similar body form and physiology, despite the ticks being larger and more conspicuous than mites. The acarines separated from the insects very early during evolution and for technical and clinical purposes they need to be considered separately, despite mites and ticks sometimes being incorrectly called insects during informal speech.

[to Contents]

Photograph shows a group of live house-dust mites, genus *Dermatophagoides*; these free-living mites are a source of allergens causing respiratory disease in humans and domestic animals. Note their size against textile fibers typical of their natural habitat. Although these mites are not parasitic they are included in the fields of medical and veterinary entomology. (Photograph by Gilles San Martin).

The body wall (integument) of acarines forms an exoskeleton typical of arthropods, but this tends to be flexible rather than stiff as in adult insects. The body is not clearly divided into segments. Segmentation has become greatly reduced during evolution so that the body consists of a small anterior portion (gnathosoma) bearing the mouthparts, and a large posterior portion (idiosoma) bearing the legs. The integument is often textured with fine striations, tubercles, or scales. Setae commonly appear on much of the body and legs. In addition there may be stout spines.[1]

Piercing mouthparts usually consist of a pair of chelicerae with cutting teeth which can be protruded from paired cheliceral sheaths. These sheaths are dorsal. A flat blade-like hypostome is ventral to the cheliceral sheaths. These sheaths and the hypostome form between them one tube for both blood-sucking and salivation. Sensory palps accompany the feeding mouthparts.

[to Contents]

Photograph shows an adult female Hard-tick, genus *Hyalomma*, an ectoparasite of livestock animals, dogs and others. Skin of host is penetrated by the long forward projecting mouthparts. This is an adult tick, showing division into a small anterior gnathosoma with the mouthparts, and a large posterior idiosoma bearing four pairs of strong legs.

Adult acarines have four pairs of legs, larvae have three pairs. Antennae are absent from acarines but many species have sensory structures on their palps and sometimes on their front legs, as Haller's organ. Eyes are present in some genera of ticks, and these are always borne on the idiosoma. The smaller mites are semi-transparent pale white or yellow. All ticks are grey or brown, also some have bright colored patterns on their dorsal surface. Hard plates of sclerotized integument are often present, especially in the family Ixodidae, called Hard-ticks after this character.

All acarines have a life-cycle with an incomplete metamorphosis, that for Soft-ticks is typical, as below (see also life-cycle of an ixodid tick: Hard ticks). There may be several nymphal stages. The life-cycle may be completed in about one week, as with the small mites permanently parasitic on their hosts, or it may take several years with the large ticks adapted for survival for long periods whilst waiting for hosts to arrive.[2]

[to Contents]

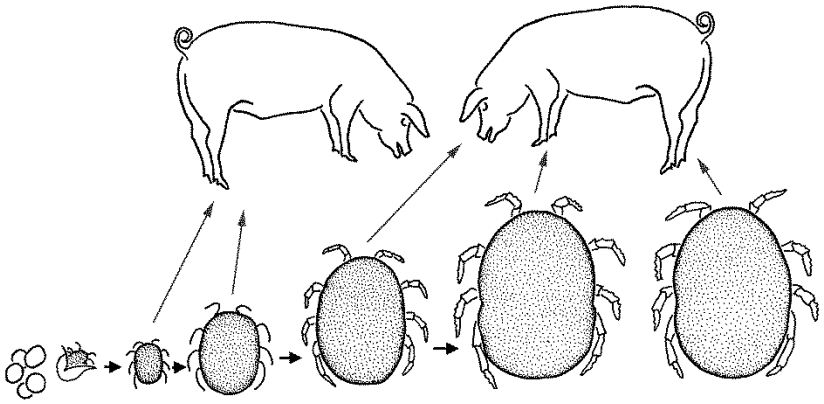


Diagram represents the life-cycle of an *Ornithodoros* Soft-tick feeding on pigs. This cycle is an incomplete metamorphosis. These Soft-ticks take multiple small meals at nymphal and adult stages of their life cycle.

Infestations with mites and ticks are often at low levels, not causing clinically significant disease, but liable to flare up into a state of disease in circumstances favourable to the parasite, such as season, or poor immune state of their host.

The information here on mites is ordered to emphasize their clinical signs and location at skin or other organs. Taxonomy of mites is complex and currently is not settled, thus it is clearer to present the mites in this book in relation to their medical and veterinary relationships.[3,4,5,6,7,8]

Glossary

- Acarine = Collective term for all the mites and all the ticks, in the Order Acarina.
- Antenna = A paired sensory organ on head of insects and other arthropods but absent from all acarines.
- Chelicerae = Paired organs that form part of the piercing structures of acarines, often long and sharp and may have moveable claws at their tips.
- Exoskeleton = Acarines, as arthropods, have an external skeleton with muscles acting on joints from inside.
- Gnathosoma = Anterior section of body of acarines, the part bearing the mouthparts and sensory palps.
- Haller's organ = Sensory pits on the fore-legs of some acarines, used for finding hosts.
- Hypostome = A paired organ of the mouthparts, acts together with the cheliceral sheaths to form a tube for blood sucking and salivation.
- Idiosoma = Posterior section of body of acarines, contains gut, reproductive organs and so on. Acarines have reduced segmentation and do not have a head, thorax and abdomen as found in insects.
- Integument = The outer body wall of acarines and insects, which also acts as their external skeleton.
- Palp = Paired and segmented sensory organs associated with the mouthparts of acarines and insects.

- Scales = Extensions of the integument of some mites, giving a distinctive surface texture.
- Setae = Thin, long, moveable extensions of the integument of acarines and insects; often very long on mites.
- Striations = Patterns of fine lines, like finger-prints, on the integument of many acarines.

References

1. Till, W.M. (1961) *A Contribution to the Anatomy and Histology of the Brown Ear Tick Rhipicephalus appendiculatus* Neumann. Pretoria, Memoirs of the Entomological Society of Southern Africa, No.6.
2. Hall, H.T.B. (1977) *Diseases and Parasites of Livestock in the Tropics*. London, Longman Group Ltd. ISBN 0-582-606187
3. Baker, A.S. (1999) *Mites and Ticks of Domestic Animals: an Identification Guide and Information Source*. London: The Stationery Office, ISBN 0-11-310049-3.
4. Walter, D.E. & Proctor, H. (2013) *Mites: Ecology, Evolution and Behavior – Life at a Microscale*. Dordrecht, Springer. ISBN 978-94-007-7163-5.
5. Krantz, G.W. (2009) *A Manual of Acarology*. Texas Tech University Press. ISBN 978-0-89672-620-8.
6. Woolley, T.A. (1988) *Acarology: Mites and Human Welfare*. New York: John Wiley & Sons, ISBN 0-471-04168-8.
7. Evans, G.M. (1992) *Principles of Acarology*. Wallingford: C.A.B. International, ISBN 0-85198-822-9.
8. McDaniel, B. (1979) *How to Know the Mites and Ticks*. Dubuque, Wm.C.Brown Company Publishers.

Surface feeders: Scab-mites, Itch-mites, Fur-mites and Trombiculids

Characters of a diverse group of surface-feeding mites

The legs are usually long, with claws at their ends and also may be equipped with terminal suckers. The first segment (coxa) may have a thickened extension (an apodeme) that joins it to the coxae of other legs. The trombiculid mites are only parasitic as larvae, which have three pairs of legs. Body profile is usually oval but circular in *Psorergates*. Psoroptic mites are relatively large but psorergatic mites are small. Mouthparts are well developed and protrude. Setae tend to be long and usually protrude from the body margin or from the ends of some pairs of legs.

[to Contents]

Photograph shows a *Psoroptes* mite from an infestation on outer ear of a rabbit, causing ear-canker.

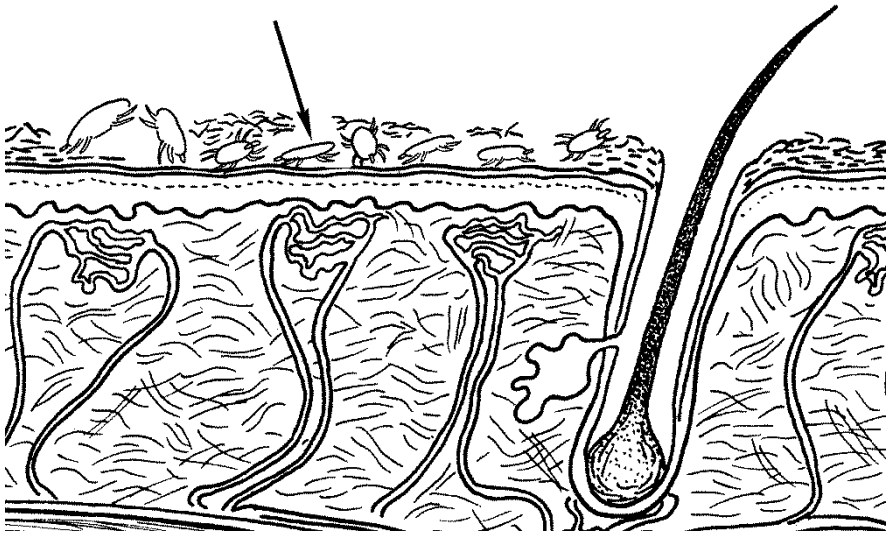


Diagram of feeding at skin represents a surface feeding mite such as *Psoroptes* within the dead layers of its host's skin (relative size of mites is exaggerated).

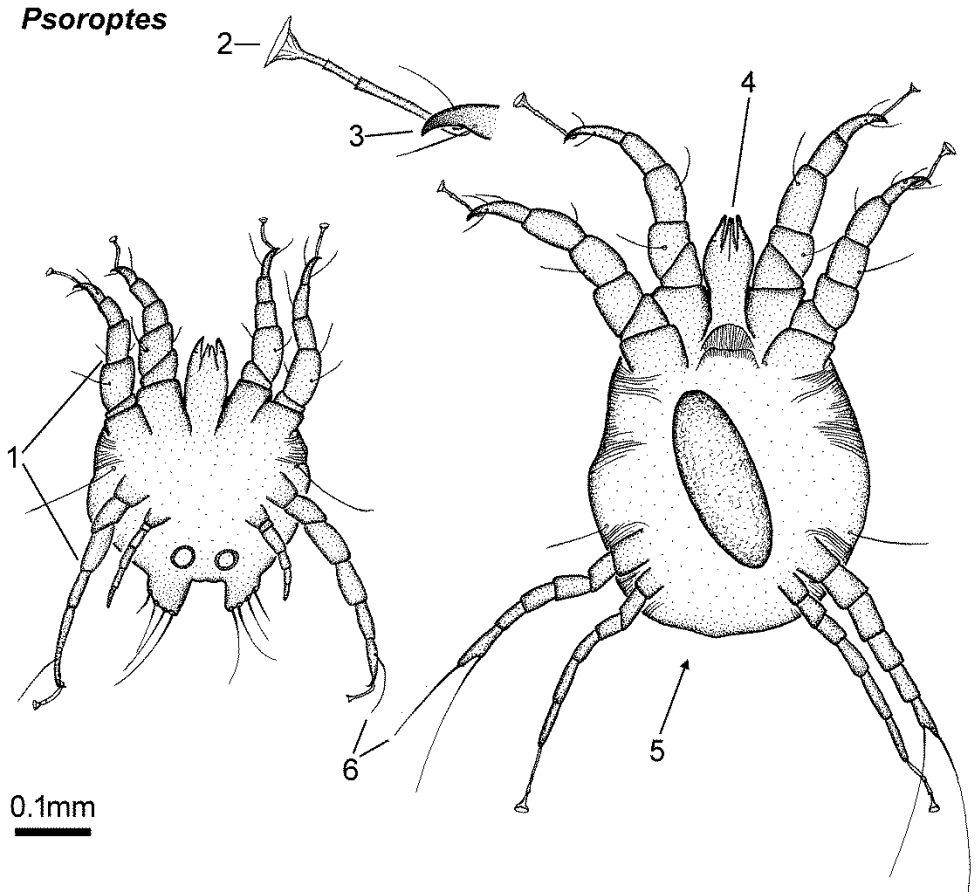
Glossary

- Apodeme = An extension of the coxa along the body wall of mites; appears like a thick line or rod (5 on *Otodectes*).
- Coxa = First segment of leg of acarines and insects, closest to the main body.
- Pedicel = Technical term for the thin stalk that carriers a sucker on the end of legs of some mites (2 on *Chorioptes*).
- Erythema = Inflammatory dilation of skin capillaries, tending to give the area a reddish color.

- Scab = In this context: a large flake of dead outer skin and dried serum, but also a vernacular term for infestation of sheep with *Psoroptes ovis* causing these scabs. Compare with mange (see Burrowing mites).
- Sucker = A cup shaped adhesive organ at the ends of some legs of some mites (2 on *Psoroptes*).
- Stratum corneum = The non-living outer layer of the skin of vertebrate animals; liable to infestation by mites.
- Stylostome = A feeding tube formed by salivary secretion of trombiculid mites, that penetrates skin of host (see diagram of trombiculid feeding).

Psoroptes (Psoroptidae, Scab-mites)

[to Contents]



Characters: male left, female right, both ventral. 1- Well developed legs protrude far from body margin. 2- Suckers are shaped like shallow cups; they are on long stalks (pedicels) on leg pairs 1, 2 and 3 of males, and legs 1, 2 and 4 of females; the stalks have rings. 3- Claws are present at ends of legs 1, 2 and 3 in males, and legs 1 and 2 in females. 4- Mouthparts are well developed and sharply pointed. 5- Adult mites are large enough to be visible to unaided vision. 6- Long setae protrude from leg pair 3 of both sexes. Also: dorsal surface has no spines, and profile of an egg shows in female at right.

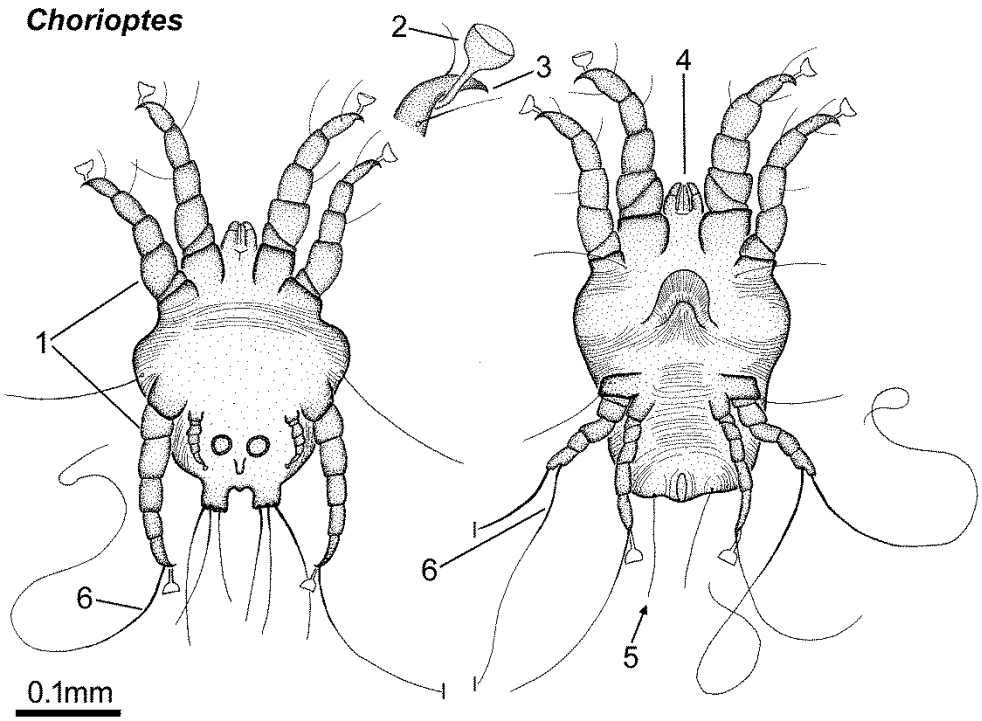
Hosts: Sheep are parasitized by *Psoroptes ovis*, the Sheep scab-mite, and this species also can feed on cattle and horses. Rabbits are the main host of

P. cuniculi; this species feeds in the outer ear and will also infest ears of sheep, cattle, horses and donkeys.

Signs and disease: Infestations of sheep start from back line and may spread as the mites progress into areas of fresh skin, leaving behind a depilated, raw and scabby skin surface. The mites remain external to and within the non-living stratum corneum where they induce an inflammatory exudate. Mites appear to feed on this exudate. Heavy infestations are conspicuous by the scabbing, depilation and severe pruritus. The itching can be so severe that it leads to distress and compulsive self-grooming by sheep. Sheep-scab is major cause of lost production. Transmission between sheep in close contact is by contagion; also these large mites can survive for days and be transmitted on fomites such as pieces of wool. *Psoroptes cuniculi* causes inflammatory otitis leading to ear canker.[1,2]

Chorioptes (Psoroptidae, Scab-mites)

[to Contents]

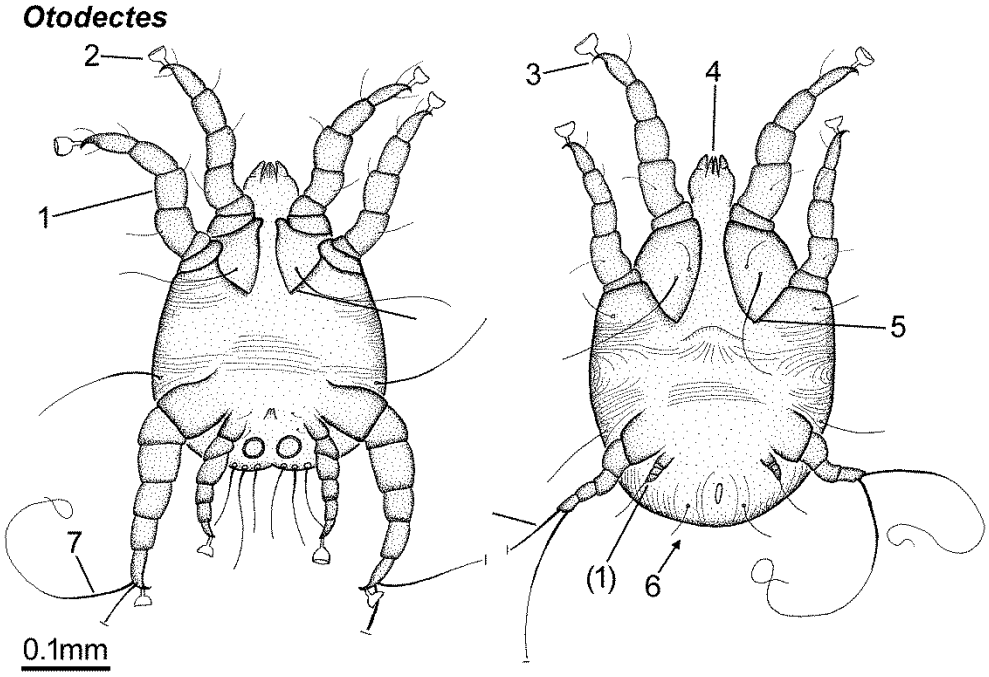


Characters: male left, female right, both ventral. 1- Well developed leg pairs protrude far from body margin. 2- Suckers are shaped like deep cups; they are on short stalks (pedicels) and are present on all leg pairs of males but those on legs 4 are very small; on females the suckers are on leg pairs 1, 2 and 4; the stalks are not ringed. 3- Claws are present at ends of legs 1, 2 and 3 in males, and legs 1 and 2 in females. 4- Mouthparts are well developed and blunt. 5- Adult mites are moderately large. 6- Very long setae protrude from legs 3 of both sexes. Also: dorsal surface has no spines.

Hosts: *Chorioptes bovis* parasitizes cattle, sheep, goats and horses.
Signs and disease: Infestations usually start from the legs or base of tail, and may spread from there. The neck and head may be infested. The etiology of *Chorioptes* scab is similar to that relating to *Psoroptes ovis* but usually forms more localized scabbing and less severe disease and loss of production.

Otodectes (Psoroptidae)

[to Contents]

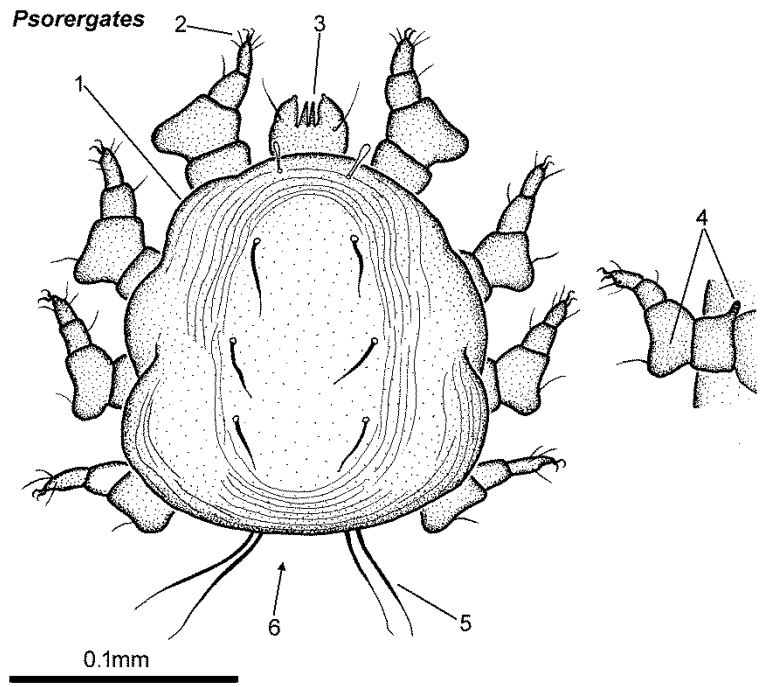


Characters: male left, female right, both ventral. 1- Well developed legs protrude far from body margin (except for legs 4 of females). 2- Suckers are shaped like deep cups; they are all of equal size, on short stalks (pedicels) and are present on all leg pairs of males, and on legs 1 and 2 of females; the stalks have no rings. 3- Claws are present at ends of legs 1, 2 and 3 of males; and on legs 1 and 2 of females. 4- Mouthparts are well developed; blunt in males, sharper in females. 5- Apodemes of legs 1 and 2 are joined. 6- Adult mites are moderately large. 7- Very long setae protrude from legs 3 of both sexes. Also: dorsal surface has no spines.

Hosts: Dogs and cats are infested.
Signs and disease: *Otodectes cynotis* parasitizes the outer surface of the skin of its host, mainly confined to the outer ear. Allergic hypersensitivity leads to parasitic otitis. Heavy infestations in some individual hosts lead to thick waxy scabs and crusts forming on the inner surface of the ear pinna where the mites feed.[3]

Psorergates (or *Psorobia*) (Psorergatidae)

[to Contents]



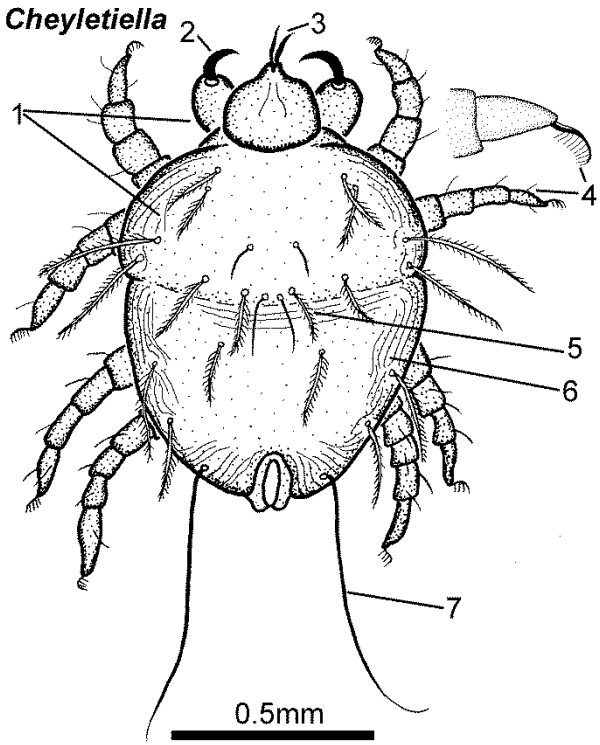
Characters: female, dorsal (inset is ventral). 1- Body profile is circular, with all legs protruding well beyond body margin. 2- Legs are thick and equipped with small paired claws. 3- Mouthparts are well developed and protrude from body margin. 4- Second segment of legs has a forward projecting spine (seen ventrally), and third segment has hooked appearance. 5- Females have 2 pairs of long setae projecting from posterior of body; males have 1 pair. 6- These mites are small.

Hosts: *Psorergates ovis* are found on sheep and *P. bos* on cattle.

Signs and disease: These mites feed within the dead layer (stratum corneum) of skin. Infestations of sheep by *P. ovis* are irritating and pruritic; heavy infestations induce intense self-grooming that may reduce the wool crop.

[Continued]

Cheyletiella (Cheyletiellidae, Fur-mites) [to Contents]



Characters: adult, dorsal. 1- Body profile shows distinctly the anterior gnathosoma and posterior idiosoma. 2- Palps are formed into very large claw-like extensions. 3- Chelicerae of mouthparts are formed into a pair of fine piercing parts. 4- Legs are well developed, project from body margin and end in claws formed like combs. 5- Setae are sparse but large and may have a finely feathered appearance. 6- Integument is partly striated. 7- A pair of large plain setae project from posterior body margin.

Hosts: *Cheyletiella blakei* (Cat fur-mite) infests the fur of cats, *C. parasitivorax* (Rabbit fur-mite) infests rabbits. These mites easily get onto other hosts, humans included, and temporarily infest them.
Signs and disease: Irritation, dermatitis, and dandruff occur; heavy infestations can sometimes build up causing erythematous pustules. These mites may also distress the owner's of the cat or rabbit.[4]

Trombiculid mites (Trombiculidae, Harvest-mites, Chiggers)

Characters of trombiculid blood-feeding mites

These mites are only parasitic during their larval stage. Eggs laid on the ground hatch into larvae which wait on vegetation for hosts. The larvae attach by secreting saliva that forms a feeding tube (stylostome) in host's

[to Contents]

skin. The larvae engorge into bright red spheres before detaching. Then they molt into the next free living stages.[5,6,7]

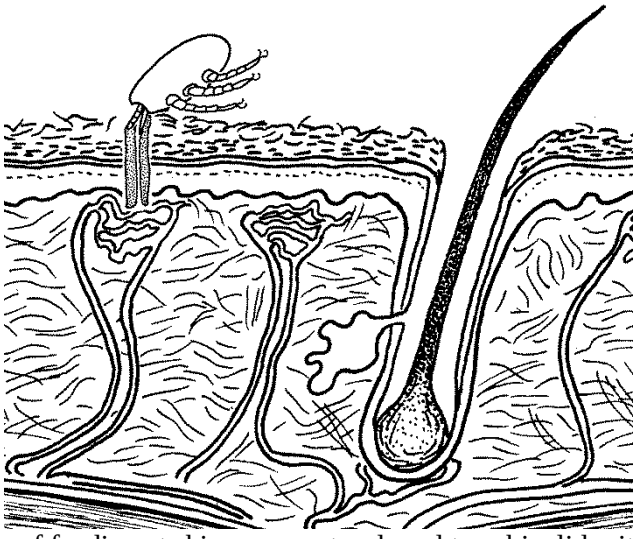
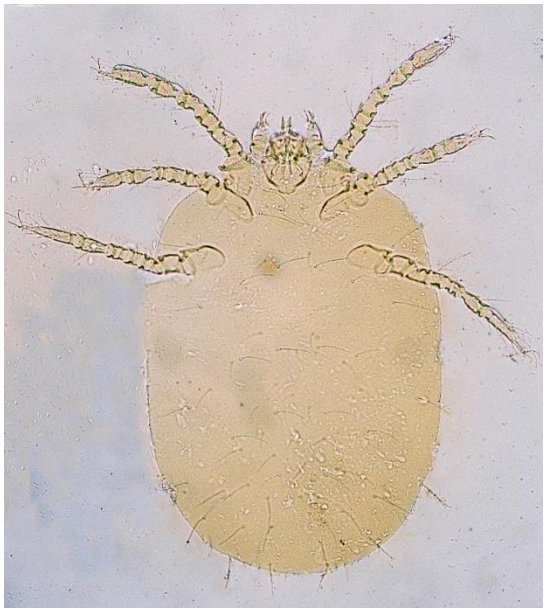
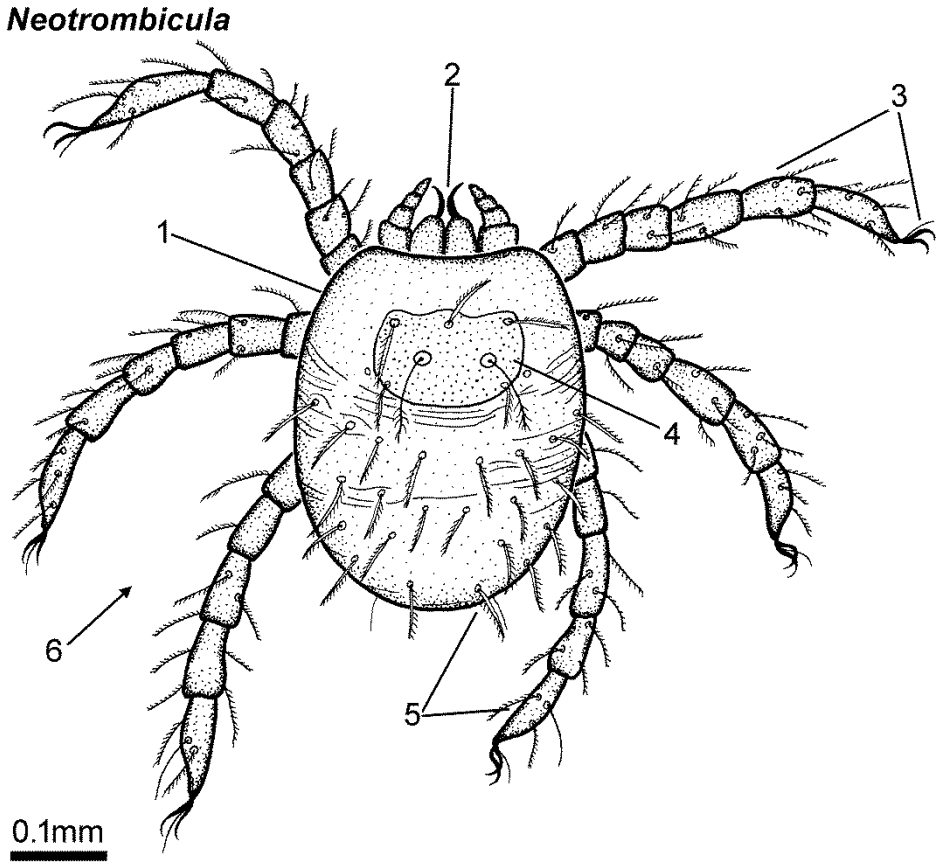


Diagram of feeding at skin represents a larval trombiculid mite. The mite produces a stylostome (feeding tube) through the epidermis of its host (relative scales not accurate).



Photograph shows a larval trombiculid mite, ventral view. As a larval acarine it has only three pairs of legs. The chelicerae and palps of the mouthparts are visible but this engorged specimen has detached from its host, leaving the stylostome feeding tube in the skin of its host.

Neotrombicula (or *Trombicula*) (Trombiculidae) [to Contents]



Characters: larva (unfed), dorsal. 1- Body profile is oval. 2- Mouthparts are well developed, with distinct chelicerae. 3- Legs (3 pairs only in larva) are well developed and protrude from body margin; they end in a pair of claws and an empodium. 4- Dorsal plate is distinct and bears several feathered setae and a pair of sensillae. 5- Body and legs have a relatively small number of large setae; some of them are smooth but most of them are feathered. 6- Unfed larvae are just visible to unaided vision.

Hosts: Larvae of trombiculid mites feed on many species of mammal: rodents, dogs, cats, rabbits, sheep, cattle, and humans. Some genera are adapted to feed on poultry birds. (Other genera of importance to domestic animals include: *Eutrombicula*, *Leptotrombidium*, *Neoschoengastia*. Vernacular names include: Harvest-mites, Berry-bugs, Scrub-itch mites, and Chiggers (but avoid confusion with names of *Tunga* fleas.)

Signs and symptoms. Irritation, and active self-grooming in response to intense pruritus are caused. The dermatitis is localized to the point where the mite fed then left behind its stylostome, which is antigenic. Engorging larvae become bright red and visible when clustering at typical sites such as the edge of ear pinna of dogs and cats. On humans the mites often crawl under clothing until the constriction of a belt or strap. There they attach and after detaching an intensely pruritic inflammation develops.

Disease: Continued exposure to numerous mites causes dermatitis and stress which can be a production problem in poultry rearing. Dogs and humans can

suffer biting stress from these infestations. Trombiculid mites are notorious as vectors of *Orientia tsutsugamushi* bacteria to humans, causing scrub-typhus or Tsutsugamushi disease.[8]

References

1. Van den Broek, A.H., & Huntley, J.F. (2003) Sheep scab: the disease, pathogenesis and control. Journal of comparative pathology, 128: 79-91.
2. Sargison, N. D., & Scott, R. (1995) Effect of an outbreak of sheep scab (*Psoroptes ovis* infestation) during mid-pregnancy on ewe body condition and lamb birthweight. The Veterinary Record, March 25, pg.287.
3. Sweatman, G.K. (1958) Biology of *Otodectes cynotis*, the ear canker mite of carnivores. Canadian Journal of Zoology, 36: 849-862.
4. Curtis, C.F. (2004) Current trends in the treatment of *Sarcoptes*, *Cheyletiella* and *Otodectes* mite infestations in dogs and cats. Veterinary Dermatology, 15: 108-114.
5. Hirst, S. (1922) *Mites Injurious to Domestic Animals*. London, British Museum (Natural History).
6. Finnegan, S. (1945) *Acari as Agents Transmitting Typhus in India, Australasia and the Far East*. London, British Museum (Natural History).
7. Wharton, G.W. & Fuller, H.S. (1952) *A Manual of the Chiggers*. Washington D.C., Entomological Society of America.
8. Traub, R. (1949) Observations on Tsutsugamushi disease (Scrub-typhus) in Assam and Burma: the mite, *Trombicula deliensis* Walch, and its relation to Scrub-typhus in Assam. American Journal of Hygiene, 50: 361-370.

Burrowing feeders: Mange mites

Characters of burrowing mange mites (Sarcoptic-mites and Knemidokoptic-mites)

[to Contents]

The legs are short, and may be equipped with terminal suckers or pulvilli. Claws are not well developed. The first segment (coxa) may have a thickened extension (an apodeme) that joins it to the coxae of other legs. Body profile is circular and these are all small mites. Mouthparts are small and do not protrude far from the body margin. Setae are mostly long and protrude from the body margin or ends of some pairs of legs. Dorsal surface has distinct striations and scales, and sometimes spines. Feeding is by burrowing through living layers of the epidermis and the life-cycle is spent entirely within skin of the host.

[to Contents]

Photograph shows *Notoedres* mange mite of cats and dogs.

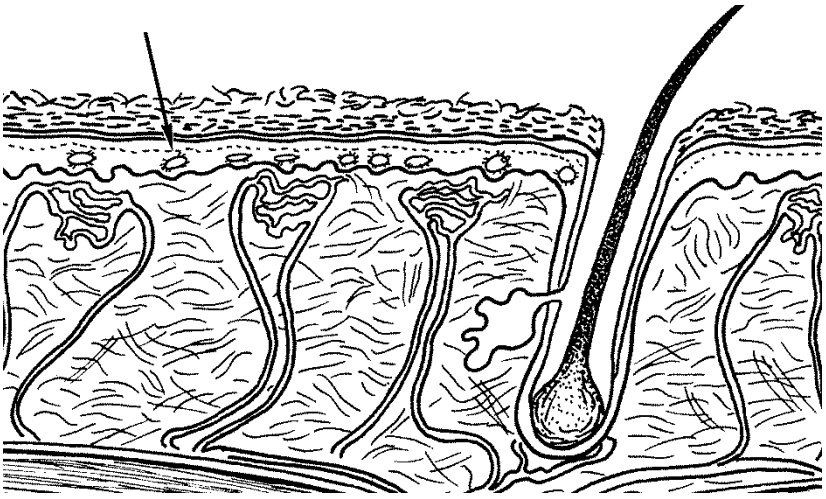


Diagram of feeding at skin represents sarcoptic burrowing mites feeding as endoparasites within the living layers of the epidermis of their host.

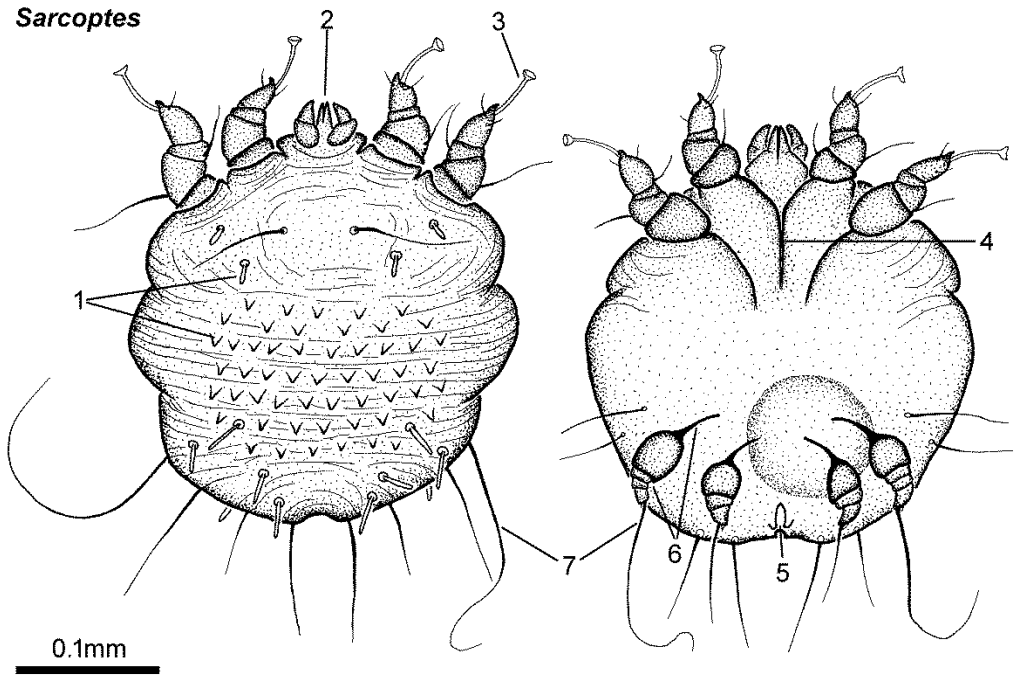
Glossary

- Hair follicle = A deep cylindrical pit in the skin of mammals formed by an inversion of the epidermis down to the root tissue forming a hair; sebaceous glands secrete into the space between the hair and epidermis. This space may be infested with *Demodex* mites (see diagram of *Demodex* feeding).
- Pulvillus = An adhesive organ on the ends of some legs of many acarines; similar to a sucker but without the distinctive cup shape of a sucker (4 on *Pneumonyssus*).
- Sucker = A cup shaped adhesive organ at the ends of some legs of some mites (3 on *Sarcoptes*).

• Zoonotic = Description of an infection or infestation that is transmissible from domestic or wild animals to humans.

Sarcoptes (Sarcoptidae, Mange-mites)

[to Contents]



Characters: females, dorsal left, ventral right. 1- Dorsal surface has a large area of spines and backward pointing scales. 2- Mouthparts are short. 3- Legs 1 and 2 have small suckers on long plain pedicels. 4- Legs 1 and 2 have the apodemes on their first segment joined in a Y shape. 5- Anus is situated ventrally. 6- Legs 3 and 4 are short and do not protrude beyond body margin; their apodemes are medium length and not joined. 7- Long setae are borne from ends of legs 3 and 4. Also: the profile of an egg is shown lower right.

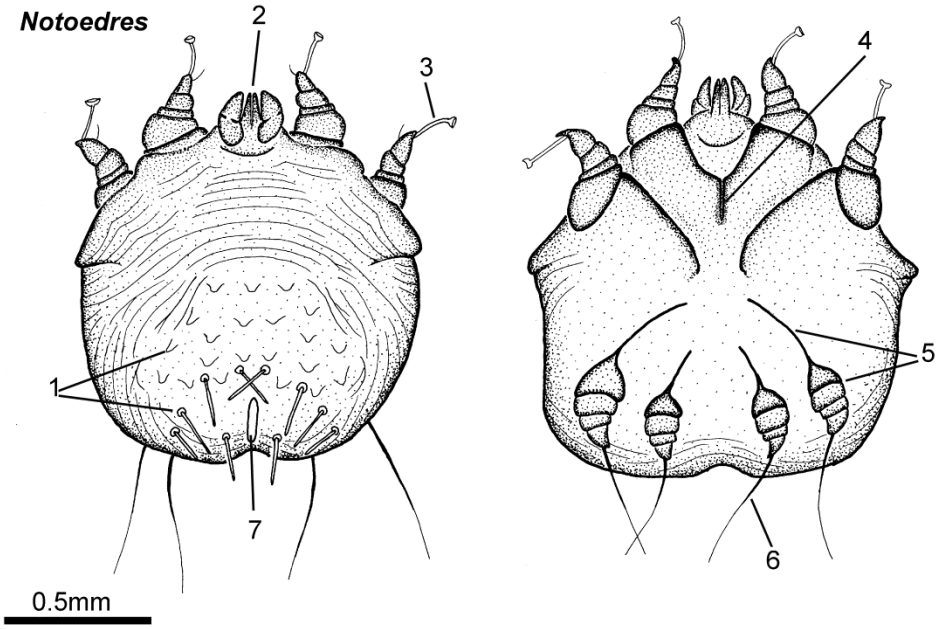
Hosts: Infestation occurs on pigs, sheep, goats, horses, donkeys, camels, dogs, and humans. Mange caused by *Sarcoptes* is one of the most damaging diseases of camels, sometimes fatal. Sites of infested skin on a typical host vary but are commonest on ears and head, back, abdomen and groin. Humans are natural hosts with infestation transmitted between themselves. Also humans are easily infested zoonotically, from close contact with infested domestic animals.

Signs and symptoms: *Sarcoptes scabiei* (Scabies-mite) forms tunnels in living layers of host skin (mainly in stratum spinosum) leaving antigenic feces. The host reacts with intense pruritus, inflammation, erythema, and thickening of skin. A secondary rash may appear at non-infested sites. Self-grooming is repeated frequently. Infestations of humans are most often found on either individuals living in severe poverty, or with larger groups of people forced to crowd together under conditions of collapsed social welfare.

Disease: Some infestations are at a low level, with little harm, but intense infestations may lead to loss of appetite and weight, with severe stress and exhaustion.[1,2,3]

Notoedres (Sarcoptidae)

[to Contents]

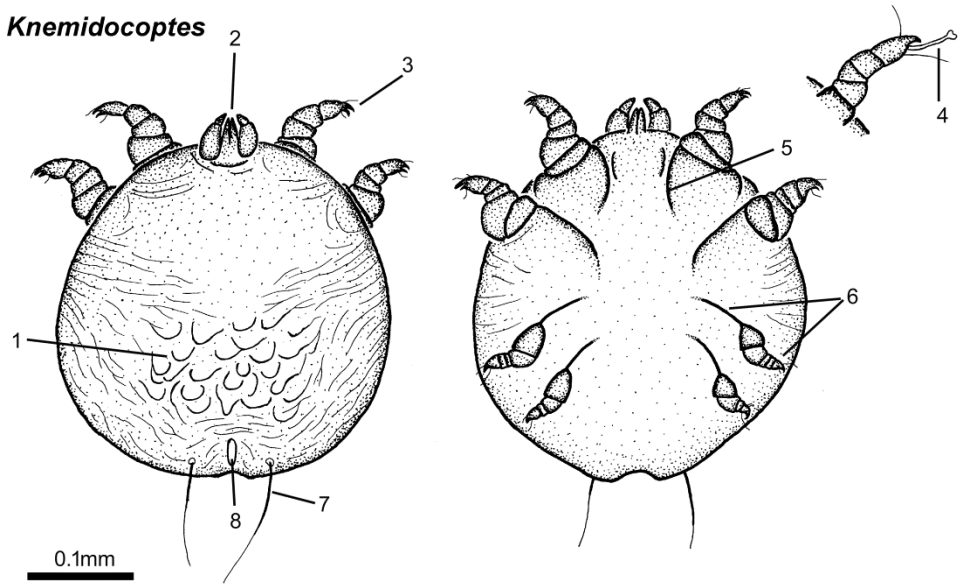


Characters: females, dorsal left, ventral right. 1- Dorsal surface has a group of setae shaped like rods, and backward pointing scales. 2- Mouthparts are short. 3- Legs 1 and 2 have small suckers on long plain stalks. 4- Legs 1 and 2 have the apodemes on their first segment joined in a Y shape. 5- Legs 3 and 4 are short and do not protrude beyond body margin; their apodemes are long and not joined. 6- Legs 3 and 4 bear long terminal setae. 7- Anus is situated dorsally.

Hosts: *Notoedres cati* burrow in living layers of skin on ears and head of cats, and may also infest dogs. *Notoedres muris* infests rats, including laboratory and pet animals.

Signs and disease: Pruritus, inflammatory and hypersensitive responses are caused, as with *Sarcoptes*. Dry and crusty lesions form at sites of infestation, together with damage to skin (excoriation) caused by self-grooming.[4]

Knemidokoptes (Knemidokoptidae) [to Contents]



Characters: females, dorsal left, ventral right, also inset is part of a male. 1- Dorsal surface has a group of irregular blunt scales; there are no spines. 2- Mouthparts are short. 3- Legs of females are without suckers or pulvilli and the setae here are short. 4- Males have all legs with pulvilli on plain stalks, and setae on legs are long. 5- Legs 1 and 2 have the apodemes separated widely (these apodemes on males are joined in a Y shape). 6- Legs 3 and 4 are short and do not protrude beyond body margin; their apodemes are long and not joined. 7- A pair of long setae protrude from posterior body margin. 8- Anus is situated dorsally.

Hosts: Birds are the hosts: *Knemidokoptes gallinae* (Depluming-mite) burrows into the feather shafts of poultry birds; *Knemidokoptes mutans* (Scaly-leg mite) burrows into the skin on feet and legs of poultry and other species of bird. (*Cnemidokoptes* or *Cnemidocoptes* are old spellings.)
Signs: The Depluming-mite will infest all feathered regions of the body. The resulting pruritus leads to the bird pulling out the feathers and the skin becomes papular and thickened. Scaly-leg mites burrow in skin of the lower parts of legs and the feet leading to deformed leg scales and nodular thickening of skin.
Disease: Heavy infestations cause stress, intensive self-grooming and anorexia, leading to loss of production.[5]

Hair follicle, airsac, lung, and cyst mites

Characters of taxonomically diverse mites infesting sheltered sites within body (a clinical grouping)

Demodex mites infest the space within a hair follicle. This space technically is external to the epidermis, but within the bulk of the skin, so *Demodex* mites can be considered as ectoparasites. *Pneumonyssus* and *Cytodites* mites

infest the sheltered habitats of nasal cavities, and airsacs and lungs respectively and thus behave as endoparasites. *Laminosioptes* mites behave as endoparasites, infesting subcutaneous tissues.

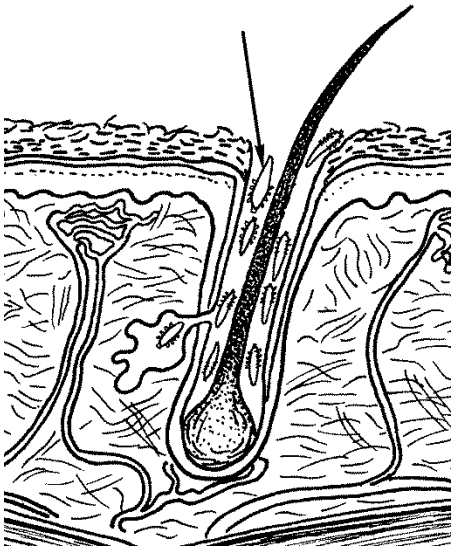
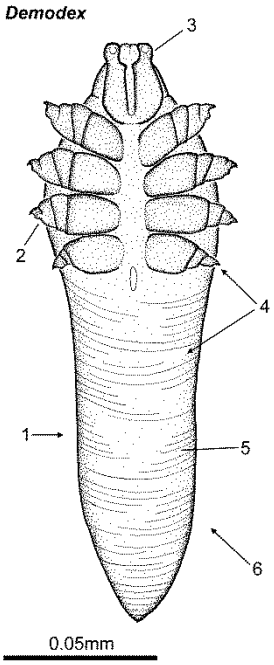


Diagram of feeding at skin represents *Demodex* mites as ectoparasites but deep within the hair follicle of their mammalian host (relative scale of mites exaggerated).

Demodex (Demodicidae, Follicle-mites)

[to Contents]

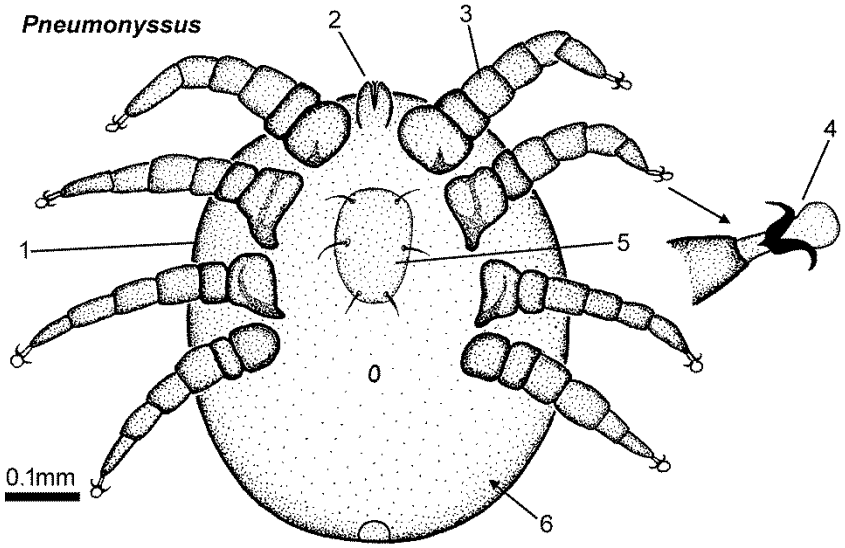


Characters: adult, ventral. 1- Body profile is uniquely distinctive: elongated to a posterior point, with four pairs of stubby legs protruding. 2- Legs end in blunt claws; pulvilli or suckers are absent. 3- Mouthparts are short and blunt. 4- Setae and similar structures on body surface are very few or absent. 5- Posterior body has many transverse striations. 6- Size of these mites is minute.

Hosts: All species of domestic mammals, also humans and many other mammals that have been investigated become infested with *Demodex* species soon after birth, by contagion during suckling.
Signs and symptoms: In domestic animals inflammatory and hypersensitive reactions to heavy infestations may sometimes lead to a widespread thickening of the skin. This thickening includes the sebaceous glands, which fill with mites and secretion. In cattle, conspicuous flat nodules form in the skin. In dogs, there is a more generalized skin thickening leading to a corrugated and depilated skin surface. Infestations of humans rarely develop into a disease state.
Disease: Most individual animals or humans develop little or no evidence of their chronic very low levels of infestation; this is parasitism without clinical pathogenicity. However, often a few individuals of a host population seem immunologically unable to prevent their *Demodex* infestations expanding. *Demodex* infestation seems not to cause pruritus, so demodecosis as a veterinary problem relates more to the disgusting appearance of heavily infested animals, especially when bacterial infections develop in the infested skin. Commercial value of cattle hides is reduced.[6]

Pneumonyssus (Halarachnidae)

[to Contents]



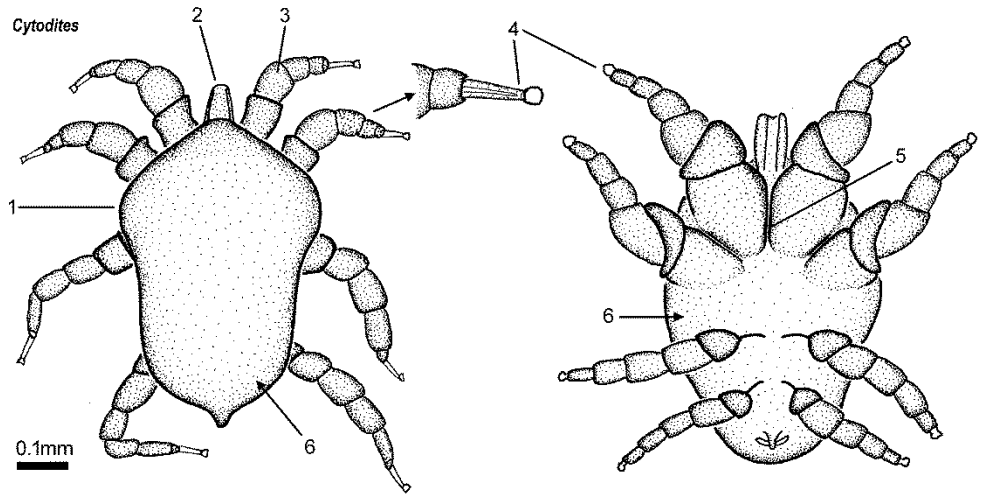
Characters: adult, ventral. 1- Body profile is a smoothly rounded oval. 2- Mouthparts are short in some species (palps may be distinct in other species). 3- All legs are stout and protrude distinctly from body margin. 4- Legs end in a pair of claws and a pulvillus. 5- A sternal plate is present, of varied shape and with pairs of setae (a dorsal plate is also present). 6- Integument is mostly smooth, without striations and with few setae.

Hosts: *Pneumonyssus caninum* (Nasal-mite) infests the nasal sinuses of dogs; *P. simicola* (Lung-mite) infests the lungs of monkeys and baboons.
Signs and disease: Nasal-mites cause head shaking, sneezing, rhinitis and sinusitis. Heavy infestations may lead to the dogs becoming listless,

anorexic and partially losing some of their sense of smell. Lung-mites infesting Rhesus monkeys are known to cause coughing and sneezing, but massive infestations sometimes occur with serious consequences.[7]

Cytodites (Cytoditidae)

[to Contents]



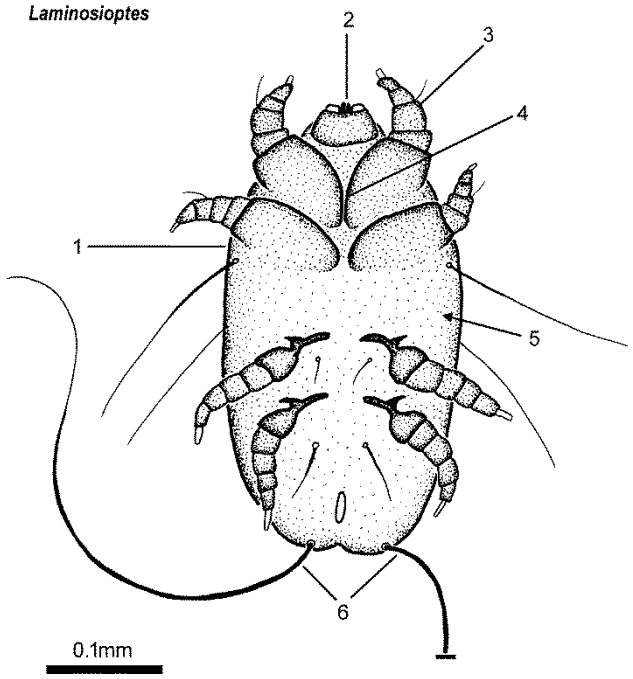
Characters: female dorsal left, male ventral right. 1- Body profile is broad anteriorly, narrowing posteriorly. 2- Mouthparts are simplified to form a sucking tube. 3- Legs are stout and protrude distinctly from body margin. 4- Legs end in a small pulvillus: in females the pulvillus is on a stalk but in males a stalk is absent. 5- First segment of legs (coxa) of males and females have their apodemes fused to form a Y shape. 6- Integument is generally smooth, without striations; setae are fine and sparse.

Hosts: *Cytodites nudus* (Airsac-mite) infests the airsacs and lungs of poultry birds and other bird species.

Signs and disease: Light infestations seem to cause little clinical problem, but if the infestation grows massive then the consequences can be fatal.[8]

[Continued]

Laminosioptes (Laminosioptidae, Cyst-mites) [to Contents]



Characters: female, ventral. 1- Body profile is an elongate oval. 2- Mouthparts are short. 3- All legs are well developed, protrude from body margin and end in stalks. 4- Apodemes of legs 1 are joined into a Y shape. 5- Integument is generally smooth, without striations; setae are distinct but sparse. 6- A pair of long setae extends from posterior margin of body.

Hosts: *Laminosioptes cysticola* (Fowl cyst-mite) infest the subcutaneous tissues of birds.

Signs and disease: Small cysts develop around the mites, widely distributed on host's body. Severe infestations can develop in some individual hosts.

References

1.Mellanby, K. (1972) *Scabies*. Hampton, England, E.W.Classey Ltd. ISBN 0-900848-61-8.

2. Arends, J.J., et al. (1990) Effects of sarcoptic mange on lactating swine and growing pigs. Journal of Animal Science, 68: 1495-1499.

3. Arlian, L.G. (1996) *Immunology of Scabies*. In: Wikel, S.K. (Ed.) *The Immunology of Host-Ectoparasitic Arthropod Relationships*, Wallingford, CAB International. ISBN 0-85199-125-4.

4. Sivajothi, S., et al. (2015) *Notoedres cati* in cats and its management. Journal of Parasitic Diseases, 39: 303-305.

5. Sreedevi, C., et al. (2015) Occurrence of *Knemidokoptes mutans* and *Laminosioptes cysticola* in backyard poultry in India. Journal of Parasitic Diseases, (Online 14 March) pgs 1-4, doi 10.1007/s12639-015-0673-1.

6. Hsu, C.K., et al. (2009) Demodicosis: a clinicopathological study. Journal of the American Academy of Dermatology, 60: 453-462.

7. Innes, J.R.M., et al. (1954) Lung mites: pulmonary acariasis as an enzootic disease caused by *Pneumonyssus simicola* in imported monkeys. The American Journal of Pathology, 30: 813.
8. McOrist, S. (1983) *Cytodites nudus* infestation of chickens. Avian Pathology, 12: 151–154. doi:10.1080/03079458308436158.

Bird mites associated with nest of hosts

Characters of nest mites of birds

[to Contents]

These are large mites with powerful legs for active crawling. They rest and reproduce in the nest or housing of their hosts. From there they seek their host for a rapid blood meal, detach and return to the nest. Their behavior is nidicolous. Mouthparts are relatively large, with long chelicerae that are either retracted within body or extended. Palps are long, of five segments.

Photograph shows a live *Dermanyssus* bird mite that feeds on blood of poultry birds; dark color showing at posterior of mite is blood in gut of mite. Chelicerae are not extended. (Photograph by Gilles San Martin).

[to Contents]

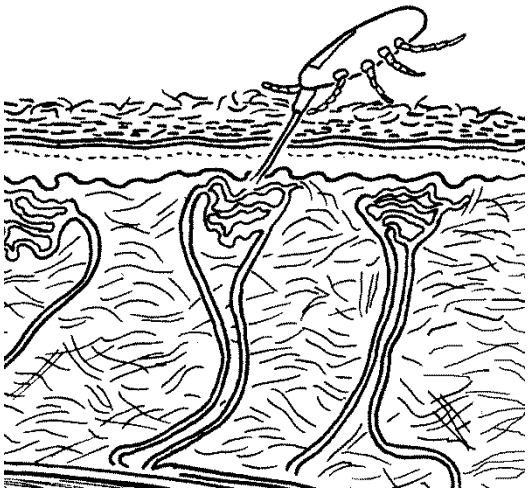


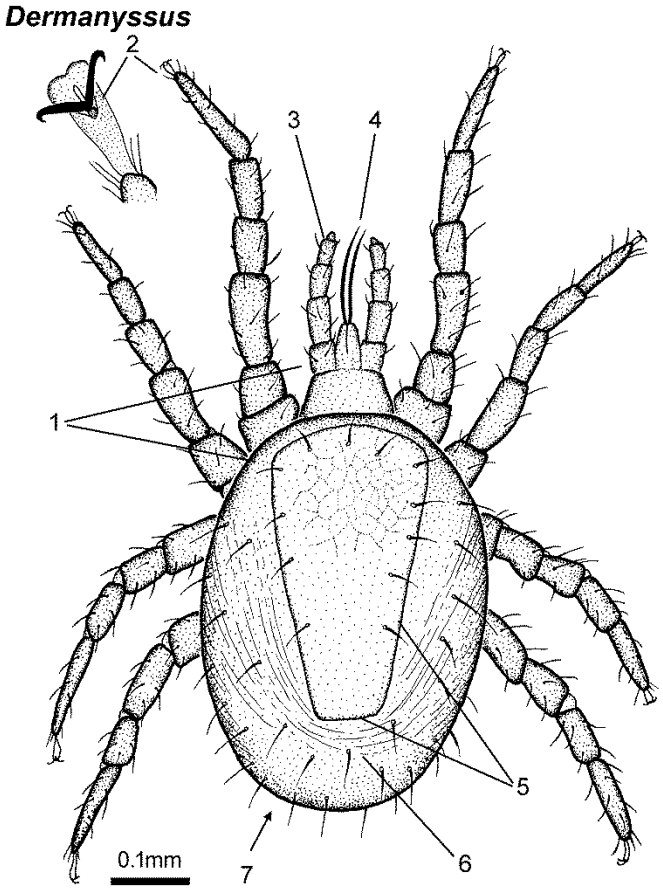
Diagram of feeding at skin represents a dermanyssid mite piercing skin of its host to obtain a blood-meal. Chelicerae are shown extended. (relative scales are not accurate).

Glossary

- Copulatory suckers = Some mites of various genera couple during mating using a pair of suckers on the female and corresponding knobs on the male (5 on *Megninia*).
- Dorsal plate = a sclerotized and symmetrically shaped area on dorsal surface of idiosoma (equivalent to scutum of Hard-ticks).
- Reticulated = Having a surface pattern of a network of fine lines (5 on *Dermanyysus*).
- Striated = Having a surface pattern of fine parallel lines, like a finger-print.

[Continued]

Dermanyssus (Dermanyssidae, Poultry-mites) [to Contents]

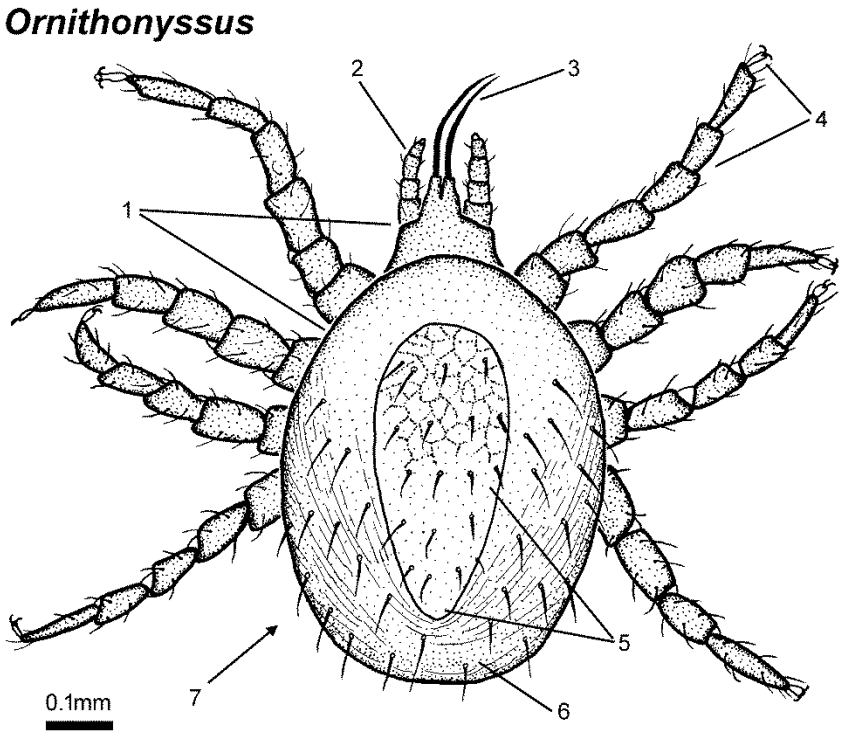


Characters: female, dorsal. 1- Body clearly divided into the anterior gnathosoma, and an oval posterior idiosoma. 2- Legs are long and end in paired claws with a pulvillus. 3- Palps are long and 5 segmented. 4- Chelicerae form a long piercing structure when fully extended from body. 5- Dorsal plate is large, approximately rectangular with a distinctly blunt posterior margin; its surface is reticulated, not striated. 6- Body and legs bear numerous long setae. 7- These mites are large, easily visible to unaided vision.

Hosts: Chickens and other poultry, caged and wild birds, are fed upon temporarily by *Dermanyssus gallinae* (Poultry red-mite). This species will feed on many species of mammal, including humans, if birds are not available. Workers in poultry houses are often bitten if infestations are allowed to build up.[1]

Signs and disease: The mite cause irritation, anemia and biting-stress. Heavy infestations can accumulate in the structure of poultry houses, leading to serious loss of production.

Ornithonyssus (Macronyssidae, Poultry-mites) [to Contents]

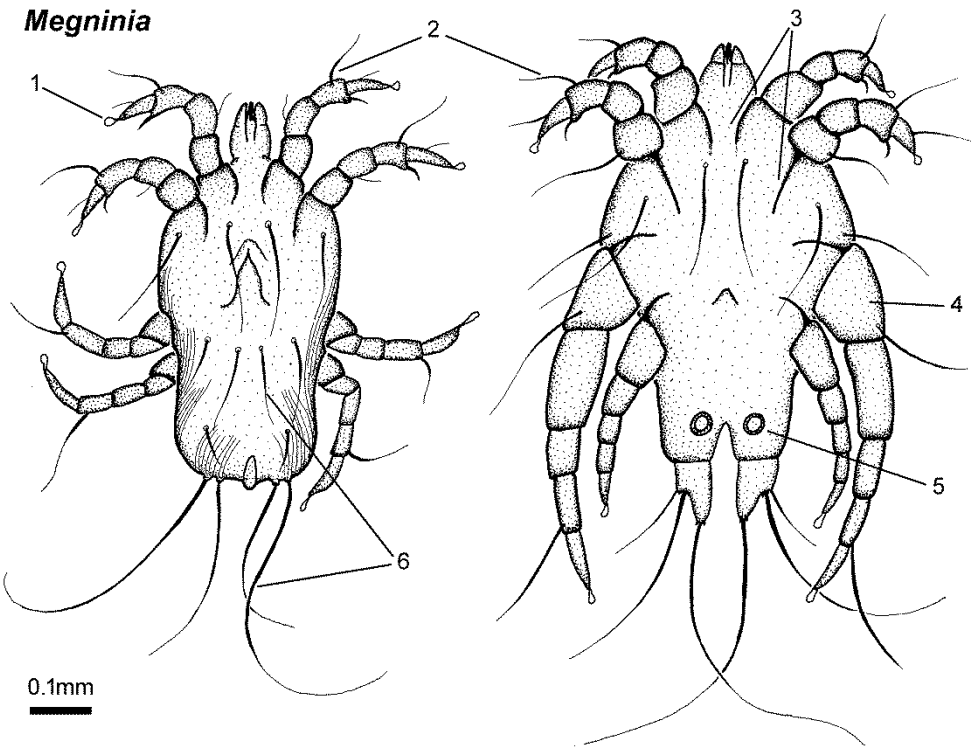


Characters: female, dorsal. 1- Body clearly divided into anterior gnathosoma, and posterior idiosoma. 2- Palps are long and 5 segmented. 3- Chelicerae form a long piercing structure when fully extended from body. 4- Legs are long and end in paired claws with a pulvillus. 5- Dorsal plate is large, oval and with a distinctly pointed posterior margin; its surface is reticulated, not striated. 6- Body and legs bear numerous long stout setae. 7- These mites are large, easily visible to unaided vision.

Hosts: *Ornithonyssus sylviarum* (Northern fowl-mite) and *O. bursa* (Tropical fowl-mite) feed on chickens and other poultry, caged and wild birds. They will feed opportunistically on mammals including humans.[2]
Signs: Irritation, restlessness, anemia, biting-stress are caused. Feathers develop a dirty and matted appearance. Dermatitis and scabbing of skin occurs, especially around the vent.
Disease: Heavy infestations can accumulate in the structure of poultry houses, leading to serious loss of production. These mites may transmit to poultry the viruses causing Fowlpox, and Newcastle disease.

Megninia (Analgidae, Feather-mites)

[to Contents]



Characters: female ventral left, male ventral right. 1- Legs end in a pulvillus. 2- Legs bear small numbers of stout setae. 3- Apodemes of both sexes are distinct but those of first coxae are not joined. 4- Third legs of males are much larger than other legs. 5- Males have a pair of terminal lobes on their idiosoma and a pair of copulatory suckers. 6- Setae on body are few but all are stout and long.

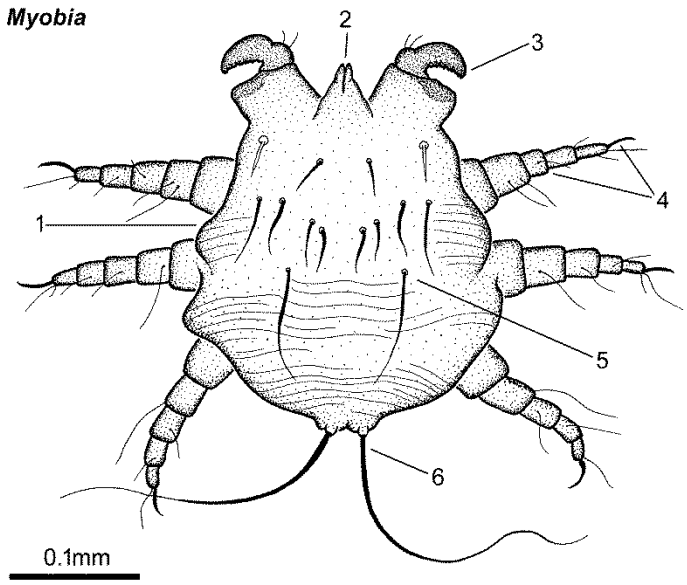
Hosts: *Megninia ginglymura* is one example of many species of Feather-mites. These infest varied species of birds, including poultry, feeding superficially, at base of feathers.
Signs and disease: Depluming, damaged feathers, irritation, and dermatitis are typical signs. Heavy infestations decrease egg production.[3]

Characters of Fur-mites of rodents

These are small mites with distinctive specialization of one or two pairs of legs adapted as large pincers to clasp onto hair of host. They spend their entire life-cycle on their host, where they feed parasitically on cutaneous tissues and liquids.

Myobia (Myobidae, Fur-mites)

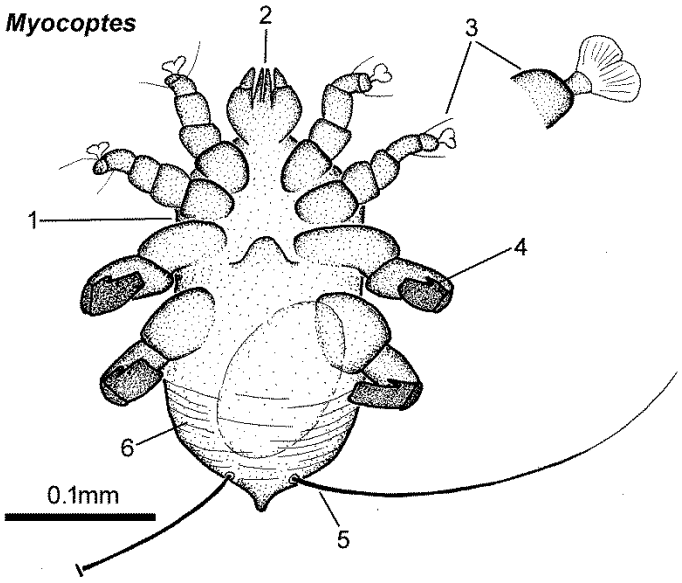
[to Contents]



Characters: adult, dorsal. 1- Body profile is an irregular circle, with distinct lateral bulges. 2- Mouthparts are small. 3- First pair of legs is modified as clasping organs. 4- Legs 2 to 4 protrude from body margin and end in a single claw. 5- Dorsal surface of body bears sparse setae of various shapes. 6- A pair of long setae protrudes from posterior body margin.

Hosts: *Myobia musculi* infests the fur of laboratory and wild mice.
Signs and disease: Heavy infestations lead to dermatitis, harsh fur or alopecia, and pruritic biting-stress.

Myocoptes (Myocoptidae, Fur-mites)



Characters: female, ventral. 1- Body profile is an irregular oval. 2- Mouthparts are well developed. 3- Legs 1 and 2 end in large pulvilli. 4- Legs 3 and 4 are modified as clasping organs. 5- A pair of long setae protrudes from posterior body margin. 6- Integument is striated (dorsally it bears 4 distinct pairs of setae). Also: profile of an egg is shown.

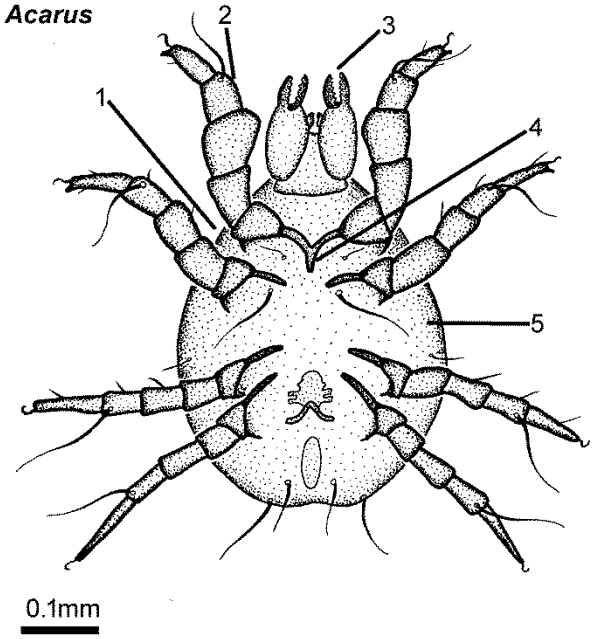
Hosts: *Myocoptes musculinus* infests the fur of laboratory and wild mice.
Signs and disease: Erythema, inflammation, dermatitis, and alopecia are typical signs. Pruritic biting-stress occurs when infestations are heavy.

Characters of taxonomically diverse, non-parasitic, mites that lead to allergies

These mites are free-living in all stages of their life-cycles. Some species feed on stored grain and hay. Other species feed on organic debris including flakes of dead skin from mammals in the same housing. The mites produce dust consisting of their dead bodies and fecal pellets. This dust readily forms airborne allergens. In confined housing this can result in various allergies to mammals, of most importance are dermatitis, rhinitis and asthma in horses, dogs, and humans. *Acarus, Glycyphagus* and *Dermatophagoides* are shown as examples of dust allergy mites. Other genera of importance are *Tyrophagus* and *Pyemotes.*[4]

Acarus (Acaridae, Grain-mites)

[to Contents]

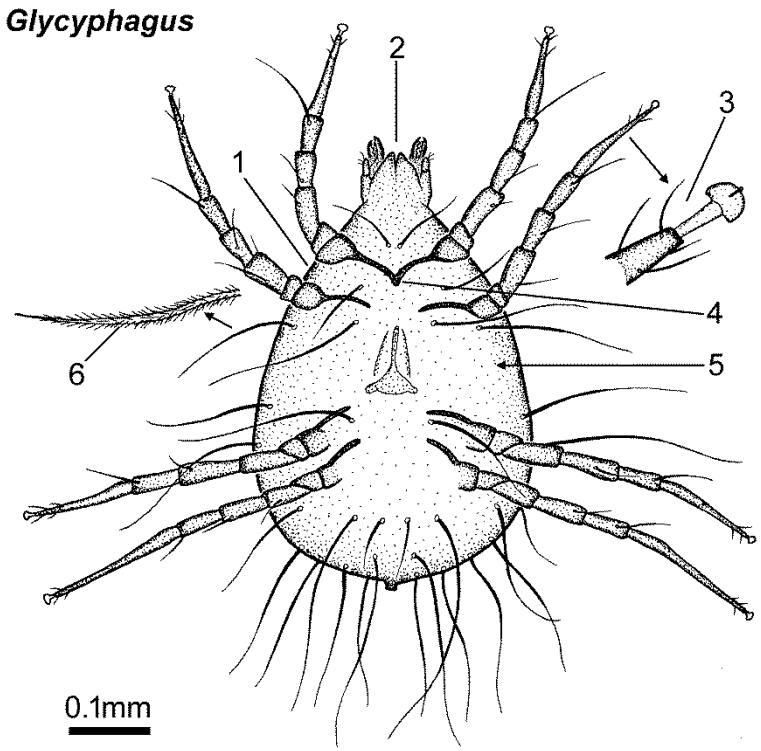


Characters: female ventral. 1- Legs are all long and end in a claw. 2- Body outline is oval. 3- Chelicerae of the mouthparts are well developed. 4- Apodemes of first legs are joined in a Y shape. 5-

Integument surface is smooth, without striations, and setae are sparse.

Note: *Acarus siro*, the Flour-mite causes allergic, digestive and metabolic problems in domestic animals exposed to them as dust or in contaminated feedstuff.

Glycyphagus (Glycyphagidae, Grain-mites) [to Contents]



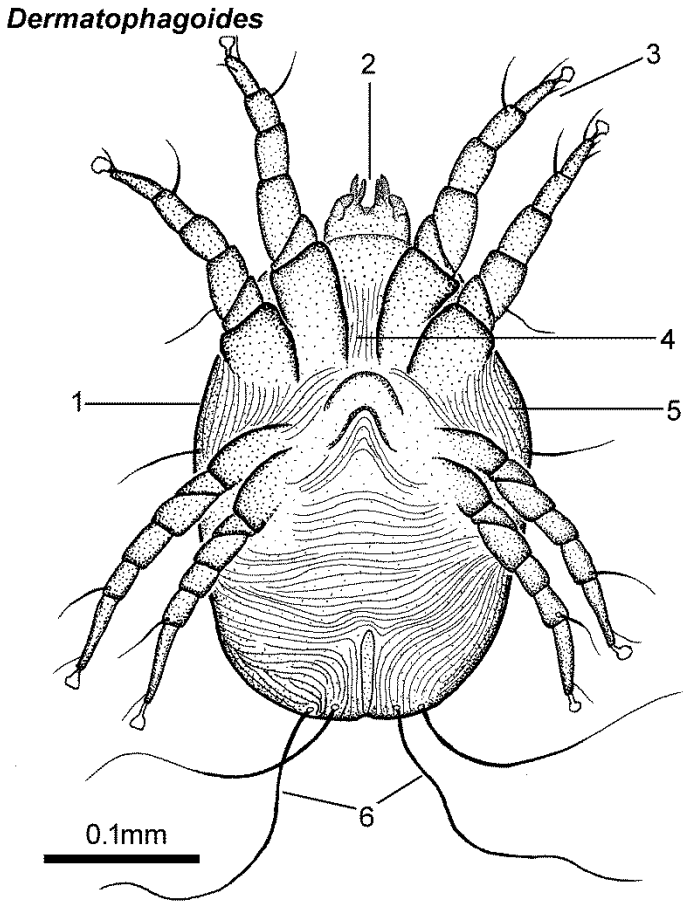
Characters: female, ventral. 1- Body profile is oval; wider posteriorly. 2- Mouthparts are prominent, with well developed chelicerae and associated palps. 3- Legs are long and end in stalks with a pulvillus. 4- Apodemes of legs 1 are joined at their tips. 5- Integument is without striations but bears many long setae. 6- Some setae are complex with finer extensions.

Note: A typical dust allergy mite that feeds on grain is *Glycyphagus domesticus* (Grocer's-itch mite).

[Continued]

Dermatophagoides (Pyroglyphidae, House-dust mites)

[to Contents]



Characters: female, ventral. 1- Body profile is a regular oval. 2- Mouthparts are prominent, with well developed chelicerae and associated palps. 3- Legs are long, stout and end in a pulvillus. 4- Apodemes of legs 1 are not joined. 5- Integument is distinctly striated; it bears few setae. 6- Two pairs of long setae project from the posterior body margin.

Note: *Dermatophagoides pteronyssinus* and *D. farinae* (House-dust mites) are typical dust allergy mites that feed on organic debris and skin flakes. See photograph of House-dust mites at start of chapter Acarines - general characters.

References

1. Chauve, C. (1998) The poultry red mite *Dermanyssus gallinae* (De Geer, 1778): current situation and future prospects for control. Veterinary Parasitology, 79: 239-245.
2. Rosen, S., Yeruham, I., & Braverman, Y. (2002) Dermatitis in humans associated with the mites *Pyemotes tritici, Dermanyssus gallinae, Ornithonyssus bacoti* and *Androlaelaps casalis* in Israel. Medical and Veterinary Entomology, 16: 442-444.

3. Rosen, S.,et al. (1988) The occurrence of *Megninia hologastra* (Analgidae Gaud, 1974) on poultry in Israel. Avian Pathology, 17: 921-923.
4. Johansson, E., et al. (1994) Allergenic characterization of *Acarus siro* and *Tyrophagus putrescentiae* and their crossreactivity with *Lepidoglyphus destructor* and *Dermatophagoides pteronyssinus*. Clinical and Experimental Allergy, 24: 743-751.

Soft ticks (Argasidae)

Characters of Soft-ticks

[to Contents]

The description soft derives from these ticks lacking hard, sclerotized, plates on their integument. However, these ticks have tough leathery integuments and can survive long periods of harsh conditions without feeding. The body profile is rounded when seen dorsally, and unfed ticks have a thin, flattened, appearance when seen laterally. Engorged ticks become fat and rounded.

Photograph shows dorsal surface of an adult *Ornithodoros* Soft-tick, with its highly textured surface and legs with humps.

Mouthparts are ventral, and small relative to size of body. There is little sign of any segmentation of the body of soft ticks; the gnathosoma bearing the mouthparts is inconspicuous and ventral. Soft-ticks never have antennae. The sexes differ externally by shape of the genital aperture (wide in females, narrow in males).

Soft-ticks mostly feed rapidly as temporary parasites without any attachment to their hosts. Their life-cycle is an incomplete metamorphosis (see Acarines - general) However: larvae of *Argas* species attach to host for about one week; larvae of *Ornithodoros* species do not feed; adult *Otobius* do not feed. Soft-ticks mostly reside within the nest or resting site of their hosts; their behavior is nidicolous.[1,2]

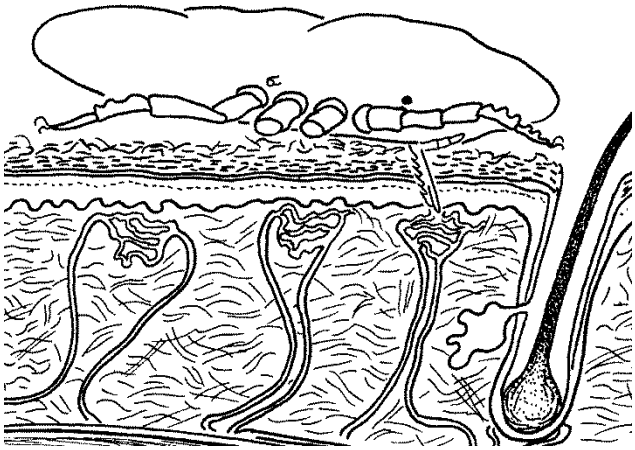


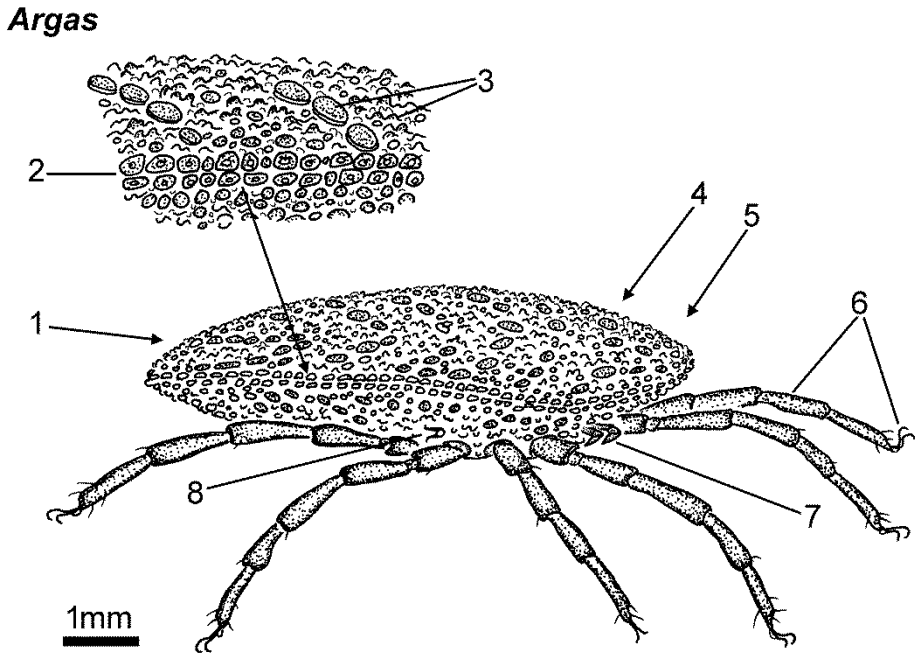
Diagram of feeding at skin represents a Soft-tick feeding by use of its piercing chelicerae to reach down to dermal capillaries. These ticks do not attach firmly to their hosts in the way that Hard-ticks do.

Glossary

- Disc = Flat, smooth, circular or oblong, raised areas on surface of integument (3 on *Argas*).
- Hump = An irregular profile of legs of some Soft-ticks (6 on *Ornithodoros*).
- Lateral suture = A distinct marginal line between dorsal and ventral surfaces of some Soft-ticks (2 on *Argas*).
- Mammillae = Small rounded protrusions forming a distinct pattern on integument of some Soft-ticks (2 on *Ornithodoros*, also photograph).
- Pulvilli = Adhesive organs on legs of some acarines but not on Soft-ticks.
- Reticulated = A pattern of a fine network on surface of some Soft-ticks (2 on *Ornithodoros*).
- Scutum = A sclerotized plate on dorsal surface of some acarines but not on Soft-ticks.
- Spiracle = Opening of respiratory system; Soft-ticks have one each side of main body, above area between leg pairs 3 and 4 (8 on *Argas*).
- Spine = A thick sharp extension of the integument of some acarines and insects (3 on *Otobius*).

Argas (Argasidae, Soft-ticks)

[to Contents]



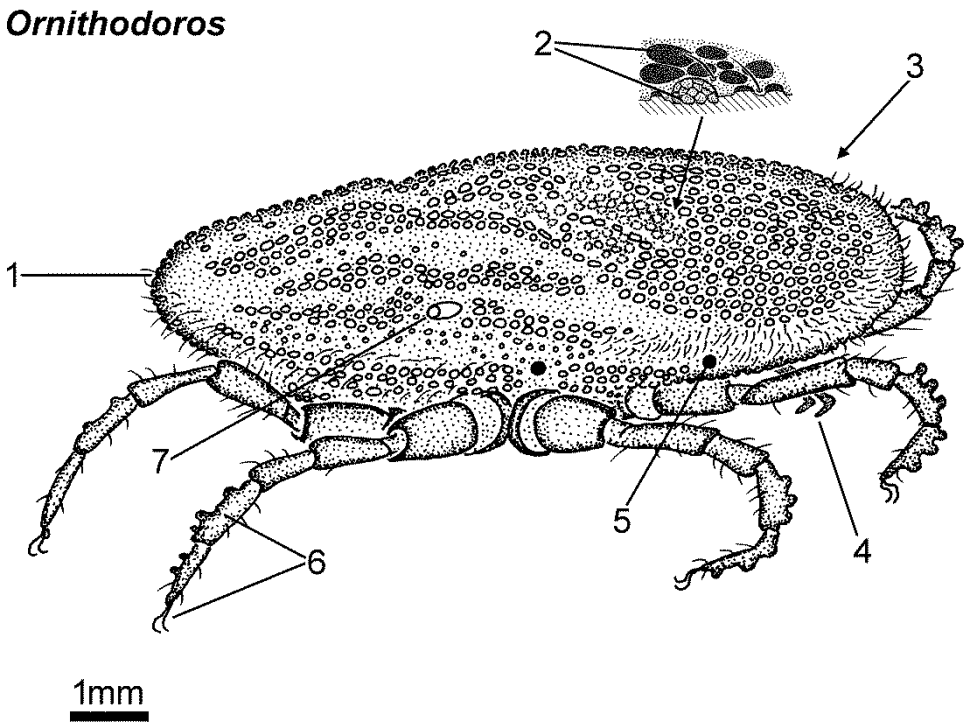
Characters: adult, lateral. 1- Body profile is a regular oval viewed dorsally; body length of adult is approx 6mm. 2- Dorsal and ventral surfaces of body meet to form a distinct lateral margin or suture. 3- Integument has rough texture of fine irregular ridges and discs; setae are sparse and short; body is yellow/brown. 4- A scutum (or dorsal plate) is never present. 5- Eyes are absent. 6- Legs are long and slender; they end in a pair of claws but pulvilli are absent; setae are sparse and short. 7- Mouthparts are small and ventral (may project anteriorly in larva of some species). 8- Spiracle is small and situated above legs 3 to 4.

Hosts: Poultry and other birds are the hosts to which these ticks are adapted. *Argas* ticks are known as Fowl-ticks, Poultry-ticks, or Tampans. *Argas persicus* and similar species are widespread pests of poultry houses, living in the structure of the bird's housing and crawling at night onto the birds to take short blood meals. This is nidicolous behavior.

Signs and disease: Feeding by these ticks causes emaciation, weakness and reduction in egg laying. Inflammation and small granulomas in skin at feeding sites develop. Signs of paralysis may occur. Large infestations of poultry houses lead to severe loss of production or death of birds. *Argas* species transmit the bacterium *Borrelia anserina* causing Avian spirochetosis.[2]

Ornithodoros (Argasidae, Soft-ticks)

[to Contents]

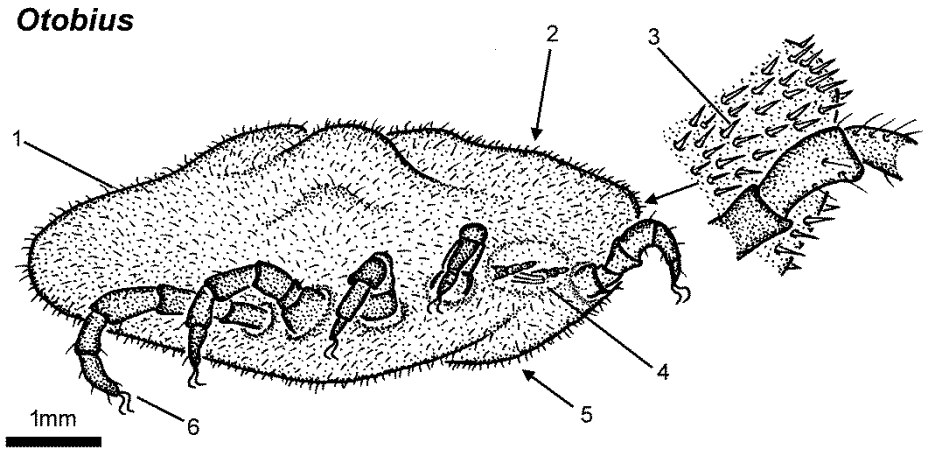


Characters: adult, lateral. 1- Body profile is an irregular oval viewed dorsally; body length of adult is approx 8mm. 2- Integument has rough texture of small rounded raised areas (mammillae) and areas with fine reticulated patterns. Setae are widespread and medium length; body is grey/brown. 3- A scutum (or dorsal plate) is never present. 4- Mouthparts are small and ventral. 5- Eyes may be present (situated laterally as one or more pairs), or eyes are absent. 6- Legs are long and their segments often bear distinct humps; legs end in a pair of claws; pulvilli are absent. 7- Spiracle is small and situated above legs 3 to 4.

Hosts: Pigs, camels, cattle, horses, donkeys and many other mammals including humans, may be fed on by these ticks. Also poultry birds may be used as hosts by immature stages of some species.
Signs: Irritation, biting-stress and signs of paralysis may occur.
Disease: The short (30 minute) feeding time of adult *Ornithodoros* is painful: tethered or housed animals may suffer severe stress, reducing production. *Ornithodoros savignyi* causes a form of toxemia when it feeds. This is not due to a toxin that is functional for the tick, in contrast to spider or scorpion venom, but the paralytic effects can sometimes be fatal. Species in the *O. moubata* complex transmit African swine fever virus between pigs, and from warthogs to pigs. They are also notorious in Africa for transmission of *Borrelia duttoni* bacteria causing Human relapsing fever to people living in mud-built houses.[4]

Otobius (Argasidae, Soft-ticks)

[to Contents]



Characters: second nymph, lateral. 1- Body profile from dorsal view varies depending on feeding and stage of development, typically it shows a widely bulging anterior part and a narrower posterior part. 2- A scutum (or dorsal plate) is never present; eyes are absent. 3- Integument is covered in thick sharp setae in the form of spines; body is grey/brown. 4- Mouthparts are small and ventral. 5- No genital aperture is present (none occur in larvae or nymphs of ticks). 6- Legs are stout, plain, and end in a pair of claws.

Hosts: Cattle, sheep and goats, horses, alpacas, dogs, and other mammals including humans are infested by the Spinose ear-tick, *Otobius megnini*. Infestations of humans are usually associated with close contact with infected horses or other domestic animals. Ticks of this small genus have an unusual life-cycle. Larvae crawl from the soil or walls of animal housing onto hosts and then to their outer ear canal to feed. Larvae molt there and feed and molt through two nymph stages in the ear. Engorged nymphs detach, molt and the females lay eggs without further feeding.

Signs and disease: These include irritation, head-shaking, anorexia, and ear canker. Biting-stress is severe and causes loss of condition. Damage to ear canal and drum may permit invasion by Screw-worms, or bacterial infection, with potentially fatal consequences.[5]

References

1. Hoogstraal, H. (1956) *African Ixodoidea, vol. 1 Ticks of The Sudan*. Cairo, U.S. Naval Medical Research Unit No. 3.
2. Okello-Onen, J. et al. (1999) *Taxonomy of African Ticks: an Identification Manual*. Nairobi, International Centre for Insect Physiology and Ecology. ISBN 92-9064-127-4.
3. Balashov, Y.S. (1972) *Blood-sucking ticks (Ixodoidea)-vectors of diseases of man and animals* Vol. 8, No 5, Miscellaneous Publications of the Entomological Society of America, Maryland, USA.
4. Schwan, T. G., & Piesman, J. (2002) Vector interactions and molecular adaptations of Lyme disease and relapsing fever spirochetes

associated with transmission by ticks. Emerging Infectious Diseases, 8: 115-121.
5. Nava, S., et al. (2009) Field and laboratory studies in a Neotropical population of the spinose ear tick, *Otobius megnini*. Medical and Veterinary Entomology, 23: 1-5.

Hard ticks (Ixodidae)

Characters of Hard-ticks

[to Contents]

These ticks are described as hard because of various hardened (sclerotized) plates on their body surface, especially the scutum (or dorsal plate). The scutum of some species contains colored pigment or enamel, making patterns known as ornamentation. The entire body is clearly divided into anterior gnathosoma bearing the mouthparts, and the posterior idiosoma bearing the scutum and legs. The profile of the idiosoma seen dorsally is a regular oval.

Photograph shows female and male Hard-ticks of genus *Amblyomma*, most species of which have distinctive colored patterns on their dorsal surface, and pale bands on their legs. The piercing mouthparts are long and stout.

[to Contents]

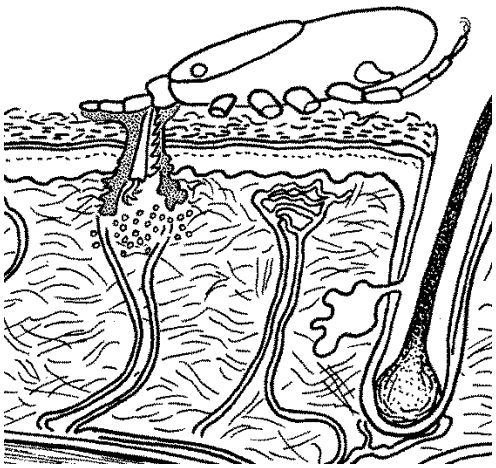


Diagram of skin represents a Hard-tick attached to its host by a salivary cement (stipple shaded). A feeding lesion is created within the host's dermis. Only the chelicerae and hypostome penetrate the skin; the palps remain superficial.

Legs are well developed. They end in a pair of claws and a pulvillus. Hard-ticks never have antennae. However, the first pair of legs have a sensory structure (Haller's organ) used in a way similar to insect's antennae. Mouthparts project anteriorly, clearly seen from dorsal or ventral views. The mouthparts (consisting of a pair of palps, cheliceral sheaths and hypostome) are borne on the basis capituli. When feeding the chelicerae and hypostome form the tube that pierces host's skin. Female ticks have a pair of porose areas on their basis capituli used for waterproofing eggs (appear similar to eyes). Eyes are present in some genera; always one pair on the anterior margins of the scutum. Females have a scutum on anterior dorsal surface of the idiosoma; males have a scutum (= conscutum) that covers the entire idiosoma. Spiracles of Hard-ticks are borne on large plates in a position posterior to leg pair 4.

Hard ticks always feed only once at each of the larva, nymph and adult stages. The feeding takes several days as larvae, to one week or more as adults. The ticks attach firmly to their host's skin. The feeding sites of hard ticks usually create a sterile abscess where the ticks feed on lymph and then whole blood at the final stage of feeding. After the ticks detach the salivary glue that they leave behind is antigenic and stimulates inflammation and formation of granulomas.

Life cycles vary from one-host, two-host or three-host. Immature stages of Hard-ticks will attach and feed on a wide variety of hosts including humans (but no species maintain their population by feeding and reproducing on humans).[1,2,3,4,5,6]

[to Contents]

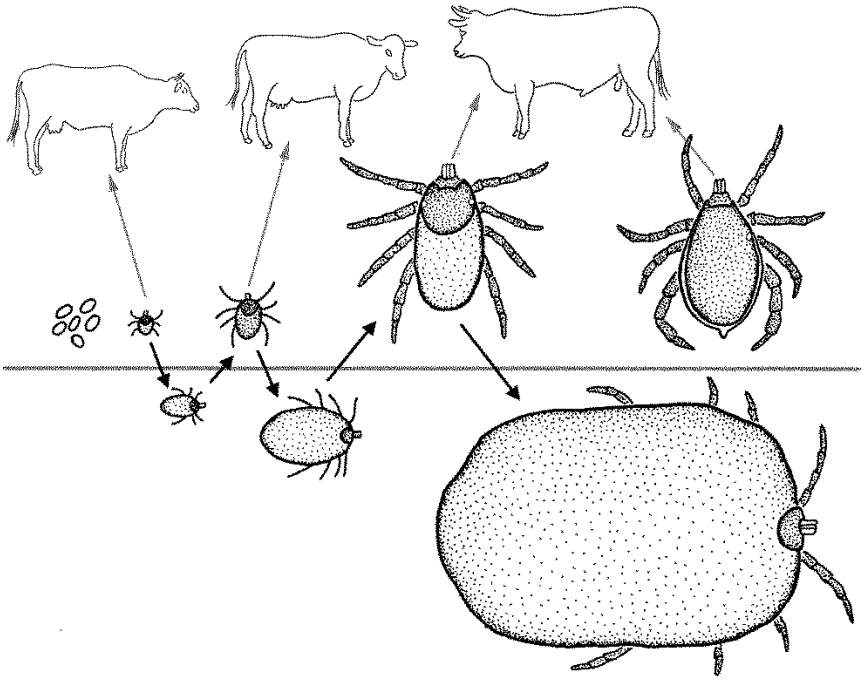


Diagram represents the life-cycle of a Hard-tick. This is an incomplete metamorphosis. There is single feed to repletion for each of the larva, nymph and adult stages, each on a separate host in a three-host feeding cycle. The non-feeding stages of two-host and three-host ticks (below the horizontal bar on diagram) are spent off the host, on ground or vegetation where the ticks molt then wait for a host to approach. Species with a one-host feeding cycle have only the egg laying female, eggs and larvae off the host on the ground or vegetation.

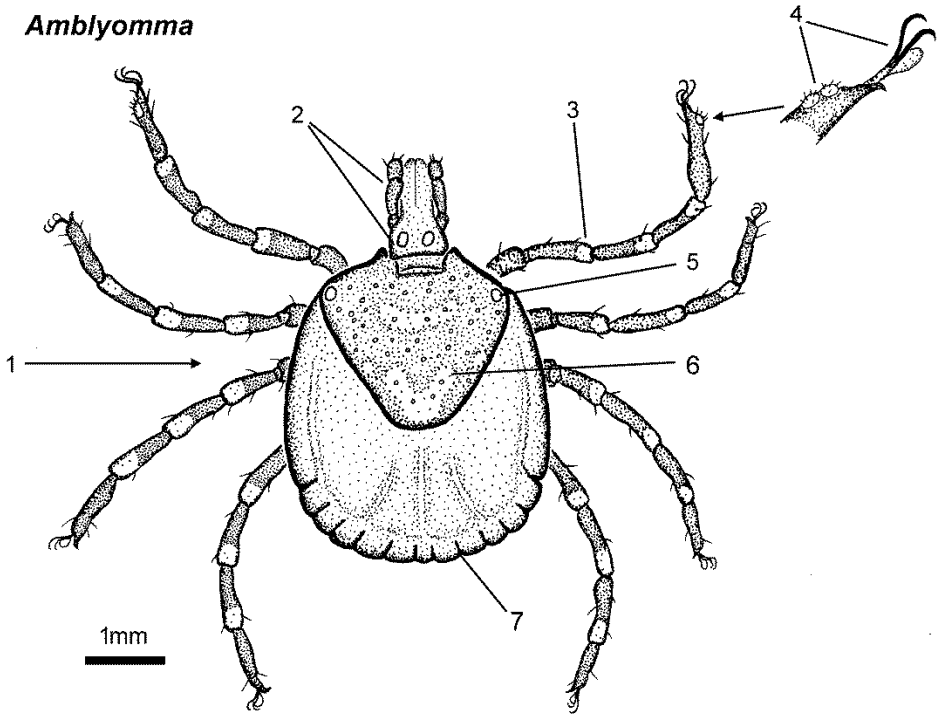
Glossary

- Anal groove = A shallow groove in the integument that is posterior or anterior to the anus (9 on *Amblyomma*, 7 on *Ixodes*).
- Basis capituli = Posterior part of the gnathosoma, bearing the anterior mouthparts.
- Conscutum = A sclerotized plate covering dorsal surface of male hard ticks (6 on male *Amblyomma*).
- Coxa 1 spurs = First segment of legs of some Hard-ticks are formed into a spur (7 on *Dermacentor*).
- Enamel = A pigment coloration of the integument, usually on scutum and conscutum and forming a pattern known as ornamentation (see photograph of *Amblyomma*)
- Eyes = Some Hard-ticks have a pair of simple eyes on the edge of the scutum or conscutum (5 on *Amblyomma*).
- Festoon = A bulge in the posterior outline of some hard ticks (6 on *Hyalomma*).
- Gnathosoma = Anterior section of body of ticks, bears the mouthparts and palps.
- Haller's organ = A sensory pit on forelegs of hard ticks (4 on *Amblyomma*).

- Porose areas = Rounded areas of pores that secrete wax to waterproof eggs, on basis capituli of female hard ticks (resemble eyes).
- Sclerotized plates = Area around anus of males of some hard ticks have characteristic plates (8 on *Hyalomma*).
- Scutum = A sclerotized plate on dorsal surface of female hard ticks (6 on female *Amblyomma*).
- Spiracle = Opening of respiratory system; on hard ticks a pair of large plates with pores posterior to coxae of hindlegs.
- Ventral plaque = A sclerotized plate on posterior integument of some hard ticks (10 on *Amblyomma*).

Amblyomma (Ixodidae, Hard-ticks)

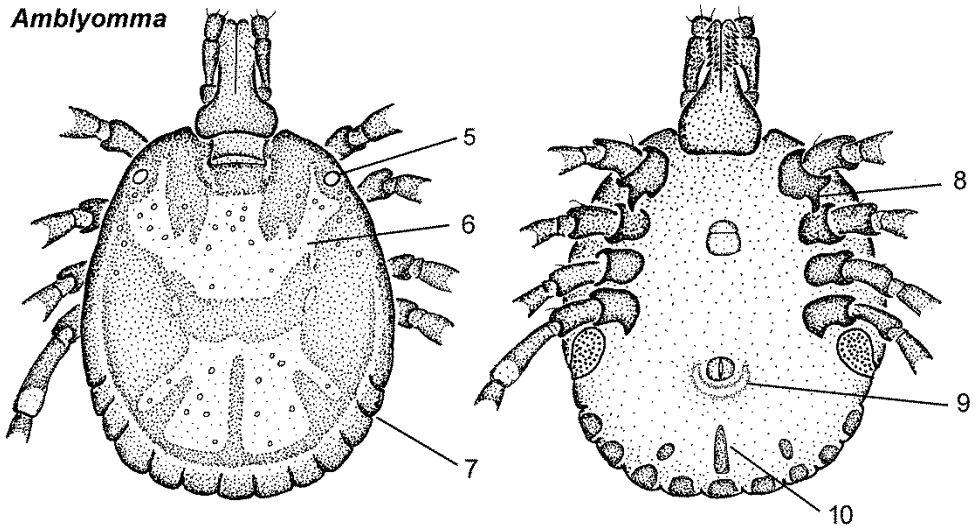
[to Contents]



Characters: female dorsal. 1- Large robust ticks, body and mouthparts up to 7mm long. 2- Mouthparts are longer than, and equal in width to, the basis capituli; basis capituli has straight lateral margins. 3- Legs have patterns of a pale ring at ends of central segments. 4- Legs end in a pair of claws and a pulvillus; first pair of legs of females has a sensory Haller's organ (these three characters are found in all hard ticks). 5- Scutum bears prominent eyes (convex or flat). 6- Scutum and conscutum of most *Amblyomma* have colored enamel forming patterns characteristic of species. 7- Posterior body margin has a series of grooves forming a pattern of festoons (not clear in engorged females).

[male *Amblyomma* continued]

[to Contents]



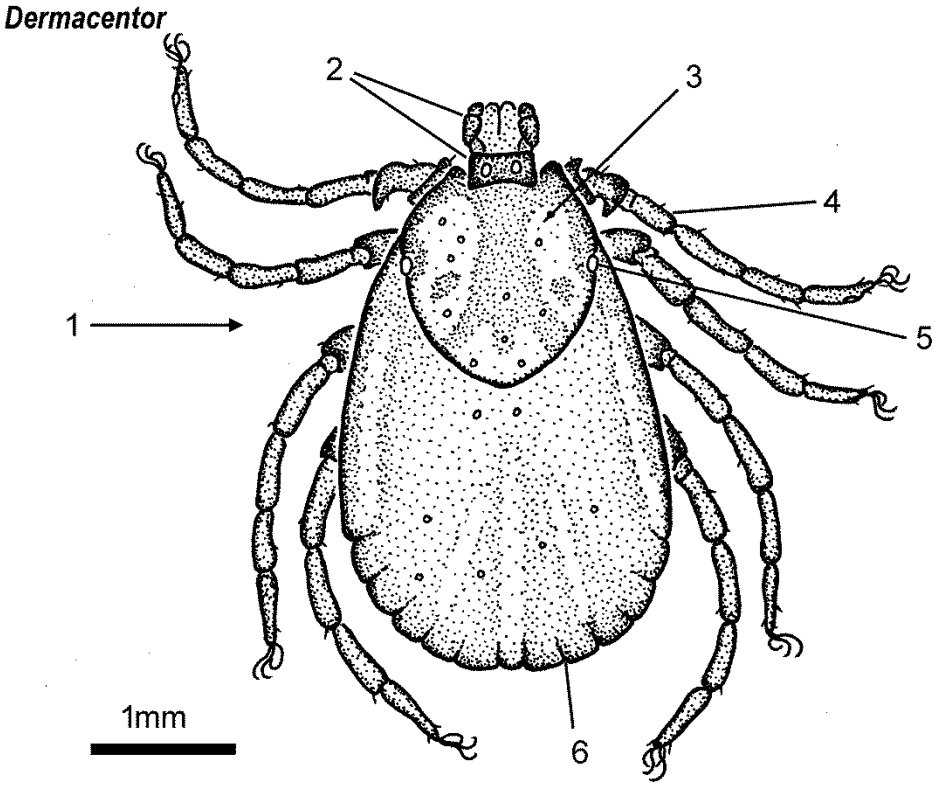
Characters: male, dorsal left and ventral right. 5- Scutum bears prominent eyes (convex or flat). 6- Conscutum of many species have distinct colored enamel forming patterns characteristic of species. 7- Posterior body margin has a series of grooves forming a pattern of festoons. 8- Coxae 1 have a large outer spur and small inner spur in both sexes. 9- A distinct anal groove is posterior to the anus in both sexes. 10 Males have no sclerotized plates aligned with the anus, but in some species there are small ventral plaques aligned with the posterior body margin.

Hosts: Cattle, sheep, goats, and many other species of mammals, birds and some reptiles are infested. Humans may be infested with larvae they have encountered on pastures.

Signs and disease: These ticks cause irritation, inflammation, and formation of dermal granulomas at the feeding sites. Feeding sites of adults become painful and biting-stress can be serious in heavy infestations leading to distinct loss of gain in weight and production of milk. A favored feeding site of adult *Amblyomma variegatum* is on the cow's teats, impeding suckling. Value of hides is reduced by formation of scars at the dermal granulomas. *Amblyomma variegatum* and *A. hebreum* transmit the bacterium *Ehrlichia ruminantium* leading to Heartwater (Cowdriosis) in cattle, sheep and goats. Feeding of *A. variegatum* causes a systemic suppression of immunity in sheep and cattle; this may allow mild infection with *Dermatophilus congolensis* bacteria to become virulent, causing severe Dermatophilosis.[7]

Dermacentor (Ixodidae, Hard-ticks)

[to Contents]

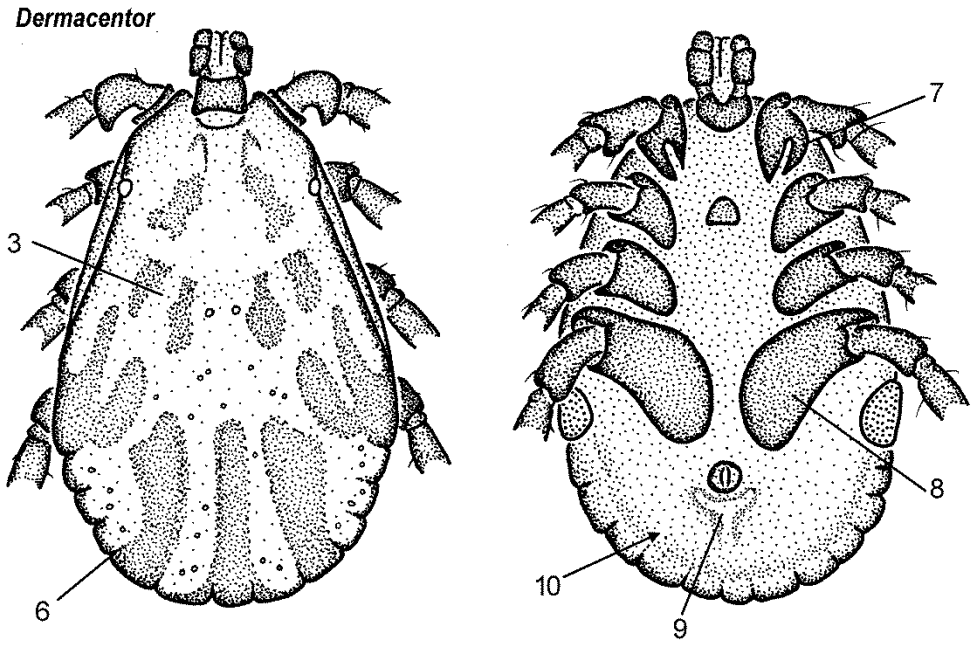


Characters: female dorsal. 1- Medium sized ticks, body and mouthparts approximately 4mm long. 2- Mouthparts are same length as the basis capituli; their width is as wide as or wider than the basis capituli; the basis capituli has straight lateral margins. 3- Scutum and conscutum of most species has a conspicuous pattern of white enamel on a dark brown background. 4- Legs are without pale rings. 5- Eyes are present (distinct in most species) 6- Posterior body margin has a series of grooves forming a pattern of festoons (not clear in engorged females).

[male *Dermacentor* continued]

Dermacentor (Ixodidae, Hard-ticks)

[to Contents]



Characters: male dorsal left, ventral right. 3- Conscutum of most species has a conspicuous pattern of white enamel on a dark brown background. 6- Posterior body margin has a series of grooves forming a pattern of festoons. 7- Coxae 1 have 2 large spurs (in both sexes). 8- Coxae of leg pair 4 are greatly enlarged. 9- Anal groove is distinct and posterior to the anus (in both sexes). 10- There are no sclerotized plates aligned with the anus.

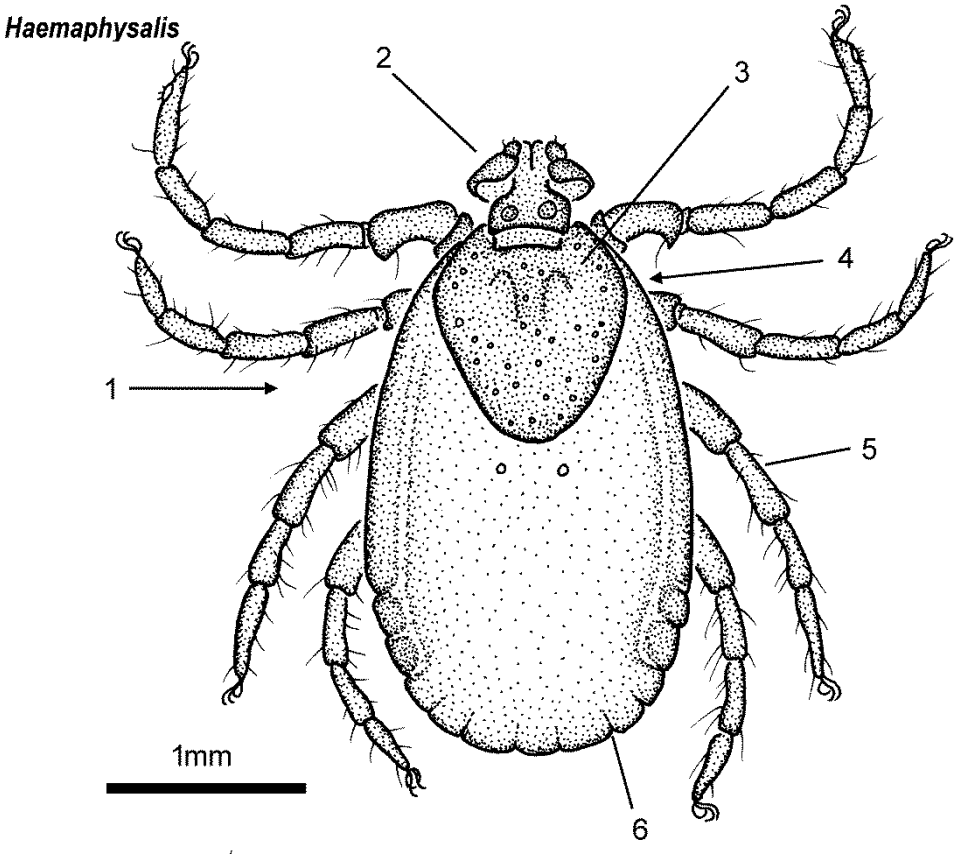
Hosts: Cattle, sheep, goats, horses, dogs, wild ungulates and small mammals are used as hosts. Humans may be infested.

Signs, symptoms and disease: Irritation and biting stress is typical. *Dermacentor andersoni* feeding as adults on cattle can cause paralysis that may lead to death (similar paralysis also happens to humans).[8,9] Infestations of horses, deer and moose by *Dermacentor albipictus* may accumulate to massive levels causing severe stress or death. *Dermacentor* species transmit to cattle, horses and dogs several species of *Anaplasma* bacteria, and *Babesia* protozoa. *Rickettsia rickettsii* causing Rocky Mountain spotted fever (tick typhus) in humans is transmitted mainly by *D. variabilis*, the American dog-tick.[10]

Distribution: *Dermacentor* species mostly inhabit temperate and cold regions, but the Tropical horse-tick, *Dermacentor nitens* of the Americas inhabits warmer regions.

Haemaphysalis (Ixodidae, Hard-ticks)

[to Contents]

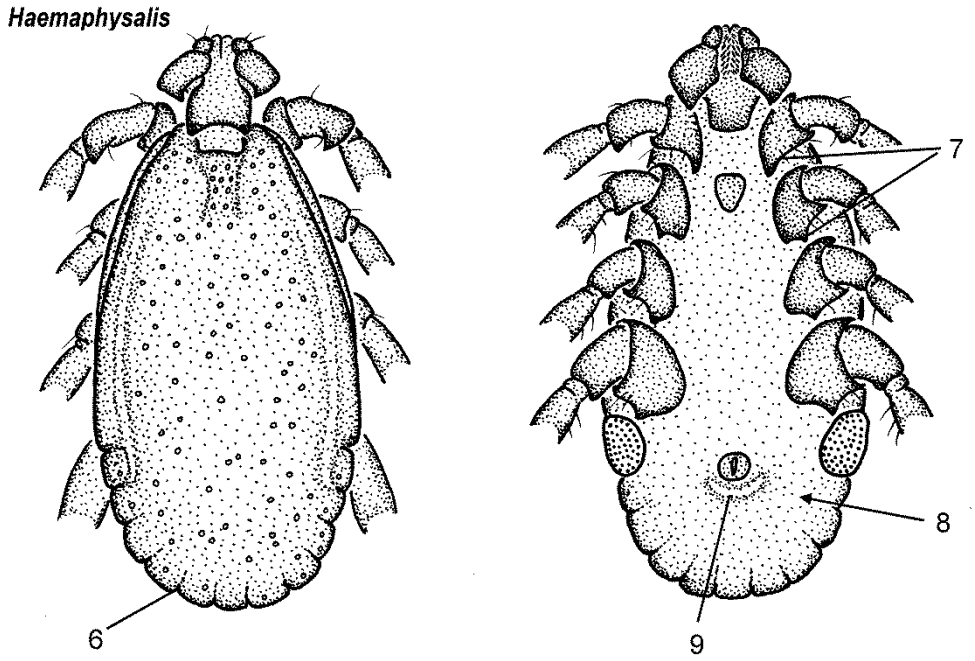


Characters: female dorsal. 1- Small ticks, body and mouthparts approximately 3mm long, body is yellow/brown. 2- Mouthparts are same length as basis capituli; second segment of palps is expanded laterally making mouthparts wider than basis capituli, and basis capituli has straight lateral margins. 3- Scutum and conscutum are plain, without colored patterns. 4- Eyes are absent. 5- Legs are without pale rings. 6- Posterior body margin has a series of grooves forming a pattern of festoons (not clear in engorged females).

[male *Haemaphysalis* continued]

Haemaphysalis (Ixodidae, Hard-ticks)

[to Contents]



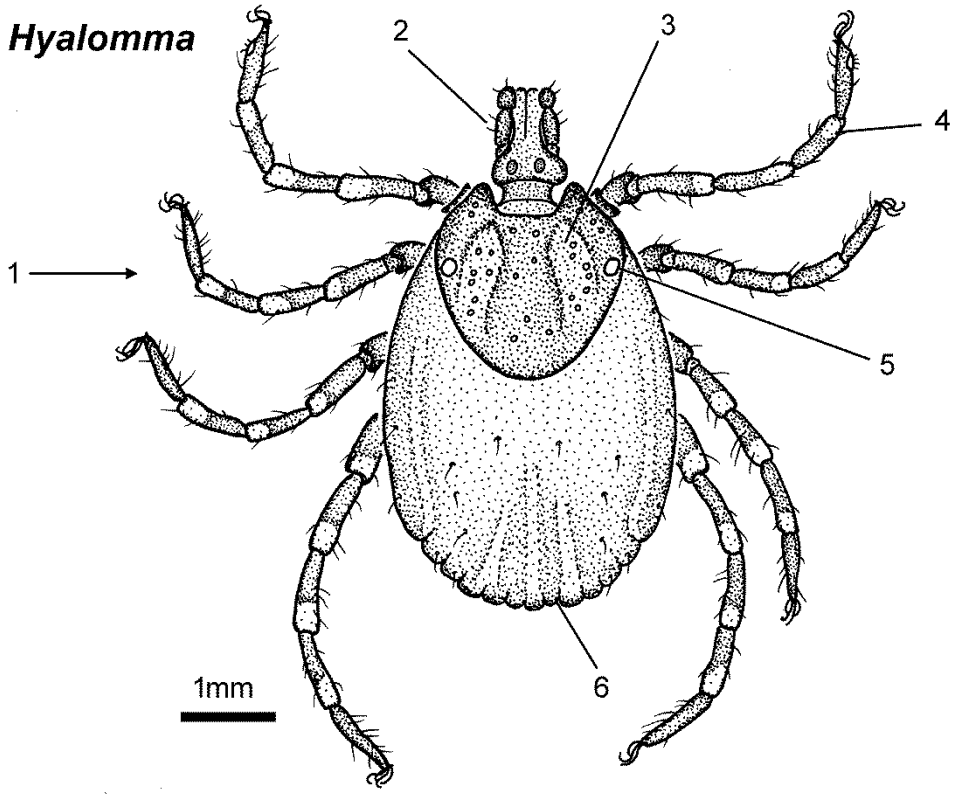
Characters: male left dorsal, right ventral. 6- Posterior body margin has a series of grooves forming a pattern of festoons. 7- Coxae 1 have a single large spur in both sexes; coxae 2 to 4 have variable sized single spurs. 8- Males have no sclerotized plates aligned with anus. 9- Anal groove is posterior to the anus in both sexes.

Hosts: Several species of *Haemaphysalis* are common parasites of livestock: *H. punctata* (Red sheep tick) and *H. sulcata* on sheep; *H. bancrofti* on sheep; *H. longicornis* on cattle, sheep and horses. Dogs are commonly infested with *H. leachi* (Yellow dog tick), more so if they have free access to bush and scrub areas. Domestic cats are resistant to infestation with ticks (or effective self groomers) but in tropical regions some *H. leachi* or *H. spinulosa* may be found on them.

Signs and disease: Irritation, inflammation at feeding sites, and pruritus are caused. *Haemaphysalis longicornis*, when heavily infesting cattle, will reduce weight gain and milk yield. Additionally, *H. leachi* transmits *Babesia canis* to dogs, and *H. punctata* transmits *Babesia major* to cattle and *Theileria ovis* to sheep.[11,12]

Hyalomma (Ixodidae, Hard-ticks)

[to Contents]

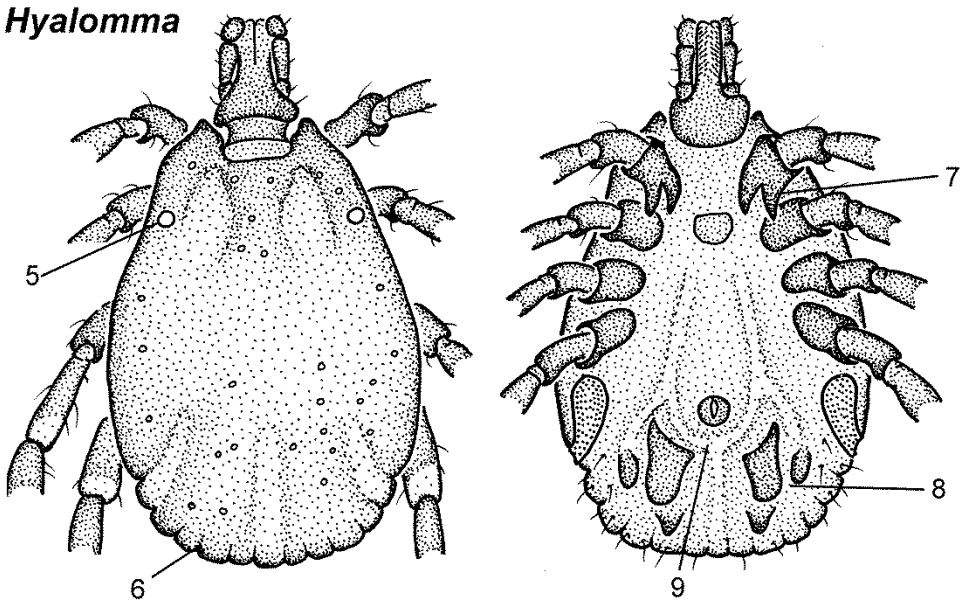


Characters: female dorsal. 1- Medium to large ticks, body and mouthparts up to 6mm long, colored dark brown. 2- Mouthparts are longer than, but same width as, the basis capituli. 3- Scutum and conscutum are plain, without colored patterns (except in a few species) and with distinct ridges and depressions, together with many punctations. 4- Legs have pale rings (except in one or more species which have white enamel on their legs). 5- Eyes are present and distinctly convex. 6- Posterior body margin has a series of grooves forming a pattern of festoons.

[male *Hyalomma* continued]

Hyalomma (Ixodidae, Hard-ticks)

[to Contents]



Characters: male left dorsal, right ventral. 5- Eyes are present and distinctly convex. 6- Posterior body margin has a series of grooves forming a pattern of festoons. 7- Coxae 1 have a pair of large spurs in both sexes. 8- Males have large sclerotized plates aligned with anus. 9- Anal groove is posterior to the anus in both sexes.

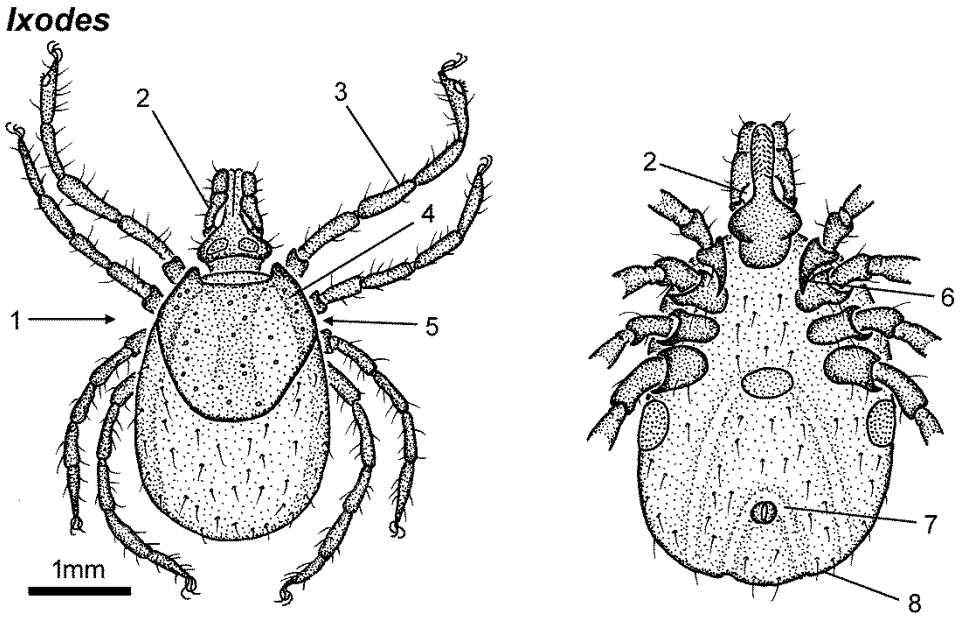
Hosts: Cattle, camels, sheep, goats, and a wide variety of wild mammals are used as hosts. Favored feeding sites vary greatly but often are sites difficult for the host to groom such as groin, peri-anal region, or between claws of host's feet. *Hyalomma aegyptium* infests tortoises.

Signs and disease: These ticks cause variously: irritation, pruritus, pain, biting stress, inflammation, formation abscesses and dermal granulomas, and toxicosis. *Hyalomma truncatum* attached at interdigital clefts on host's feet cause lameness; the same species clustering on dogs cause skin necrosis. Engorging females of *Hyalomma rufipes* often cause a salivary toxemia in their hosts: as paralysis in camels, and as a depilating moist eczema called Sweating sickness in cattle. *Hyalomma anatolicum* transmits *Theileria annulata* protozoa between cattle, leading to Tropical theileriosis. These noxious blood-suckers are also serious threats to health of humans, to whom immature stages of *H. marginatum* transmit the virus causing Congo Crimea hemorrhagic fever.[13,14]

Distribution: *Hyalomma* ticks occur in dry and seasonally hot areas of Africa, Middle East, and Asia.

Ixodes (Ixodidae, Hard-ticks)

[to Contents]

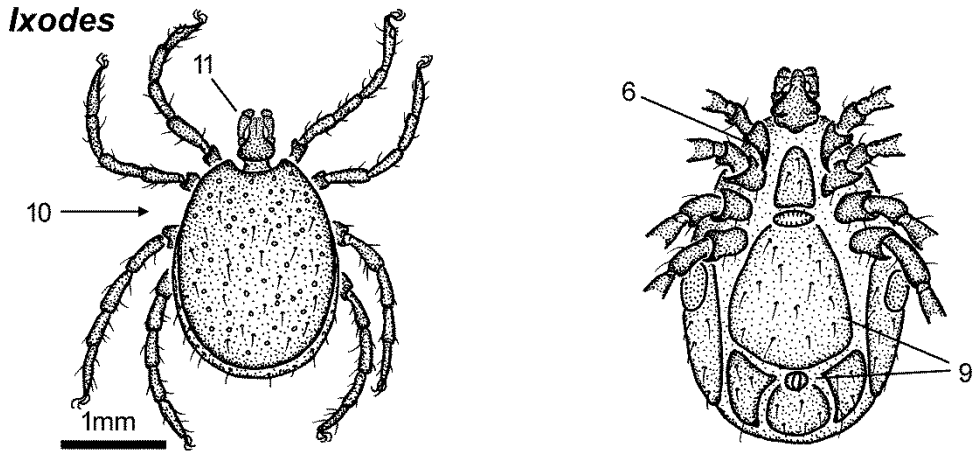


Characters: female left dorsal, right ventral. 1- Females are medium size ticks, body and mouthparts approximately 4mm long; colored red/brown and black. 2- Mouthparts of females are longer than the basis capituli; second segment of the palps bends away from the piercing mouthparts, forming a gap. 3- Legs have no pale rings. 4- Scutum and conscutum are plain, without colored patterns. 5- Eyes are absent. 6- Coxae 1 have a single large spur. 7- Anal groove runs anterior to the anus. 8- Posterior body margin has no festoons.

[male *Ixodes* continued]

Ixodes (Ixodidae, Hard-ticks)

[to Contents]



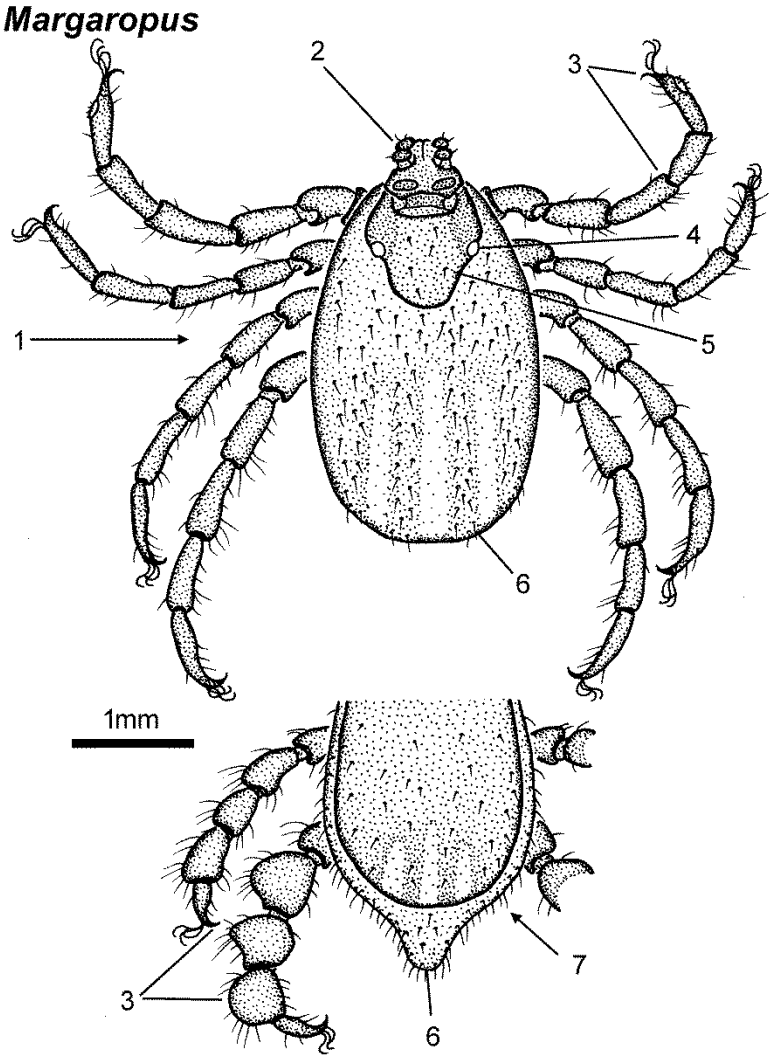
Characters: male left dorsal, right ventral. 6- Coxae 1 have a single large spur. 9- Males have large sclerotized plates covering much of their ventral surface; anal groove running anterior to the anus is defined by some of these plates. 10- Males are smaller than females of same species; they are colored brown/black. 11- Mouthparts of males are smaller than those of females.

Hosts: Cattle, sheep, goats and dogs are the principal species of domestic animal infested by species such as *Ixodes ricinus*. Deer also support all stages of ticks of this genus and are often the maintenance host in an area. Many *Ixodes* species will feed on a wide variety of mammals and birds, and humans are readily infested by larvae and nymphs.

Signs and disease: Irritation, inflammation, and pruritus are caused. Paralysis of hosts is caused specifically by feeding adults of *I. rubicundus* in the Republic of South Africa and *I. holocyclus* in Australia (these paralyses are associated with the ticks feeding on hosts of exotic species that are not the indigenous host species the ticks have evolved with). *Ixodes* species transmit *Babesia divergens* to cattle; *Anaplasma phagocytophilum* and Louping ill virus to sheep. Several species of *Ixodes* are notorious in human health as vectors of the *Borrelia* bacteria causing Lyme disease, and of the virus of Tick-borne encephalitis.[15]

Margaropus (Ixodidae, Hard-ticks)

[to Contents]



Characters: female dorsal; male, dorsal posterior. 1- Small ticks; body and mouthparts approximately 3mm long; colored brown. 2- Mouthparts are shorter than but same width as the basis capituli. 3- Legs are long and stout; they end in a distinct spur as well as a pair of claws and a pulvillus (males of *M. winthemi* have legs 3 and 4 with bulging segments). 4- Eyes are distinct in females (indistinct in males). 5- Scutum is plain (both sexes), without colored patterns. 6- Female posterior body margin has no festoons; male posterior body margin has no festoons but a terminal bulge (caudal appendage) is present. 7- Ventrally, a pair of sclerotized plates is aligned with anus, and anal groove is indistinct.

Hosts and disease: Cattle and horses are infested on widely spread areas of their bodies by *M. winthemi* (Beady legged tick). This tick species is active during winter and may accumulate on horses sufficient to cause loss of condition (this tick is also known as Winter horse tick).[16,17]

Distribution: *Margaropus winthemi* occurs only in Republic of South Africa; *M. wileyi* and *M. reidi* are found on giraffes in Kenya and Sudan respectively. These three species comprise the entire genus.

Rhipicephalus (Ixodidae, Hard-ticks)

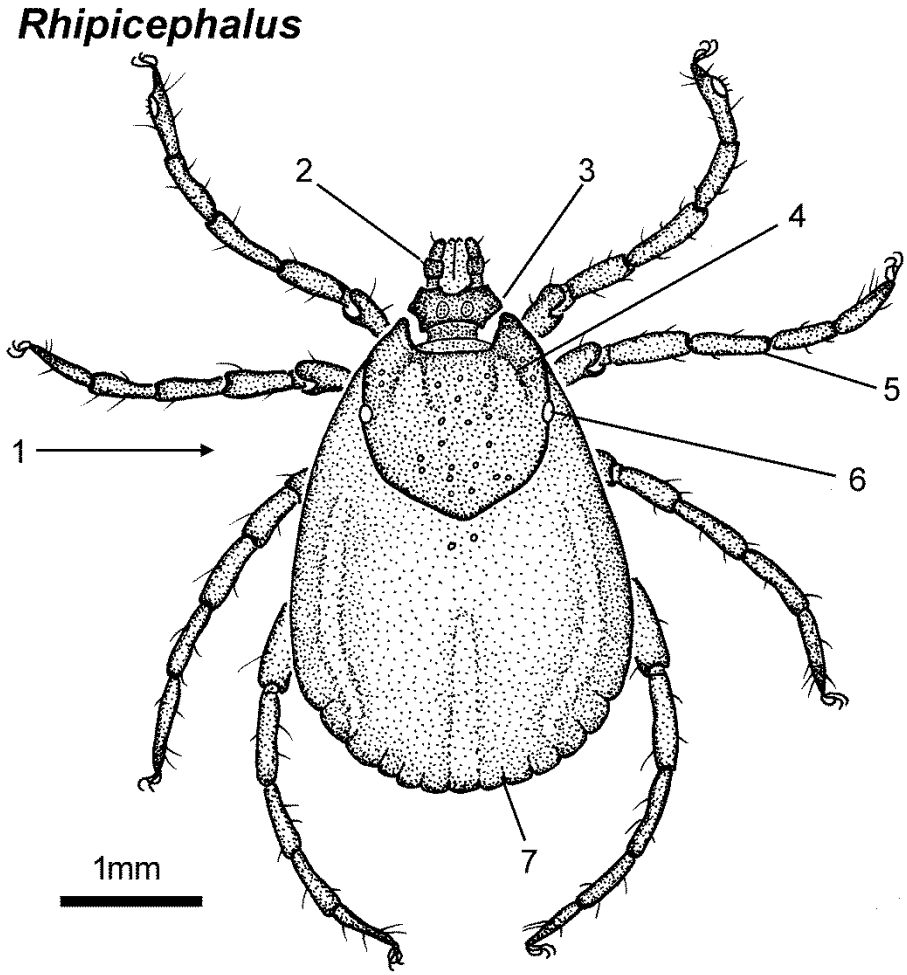
[to Contents]

Note on ticks in the sub-genus *Boophilus* (Blue-ticks, Cattle-ticks). Six species (boophilid ticks) within the genus *Rhipicephalus* have adapted to parasitism so well that they have a one-host feeding cycle, become small and have reduced distinctiveness of morphological characters. All the listed characters for *Rhipicephalus* apply to these boophilid species, so these ticks can easily be identified as members of this sub-genus. The Cattle-tick of the tropics and sub-tropics, widespread and important in large areas of the World, is a boophilid – *Rhipicephalus (Boophilus) microplus*, or simply *Rhipicephalus microplus*. The genus *Boophilus* has been placed within the genus *Rhipicephalus* because of affinities shown by its nucleic acids.[18] However, it remains convenient and understood to use the original names.

Rhipicephalus appendiculatus female and male upper row, *Rhipicephalus microplus* female and male lower row; to show differences in general appearance that may be found within a single genus (a single photograph with identical scale throughout).

Rhipicephalus (Ixodidae, Hard-ticks)

[to Contents]

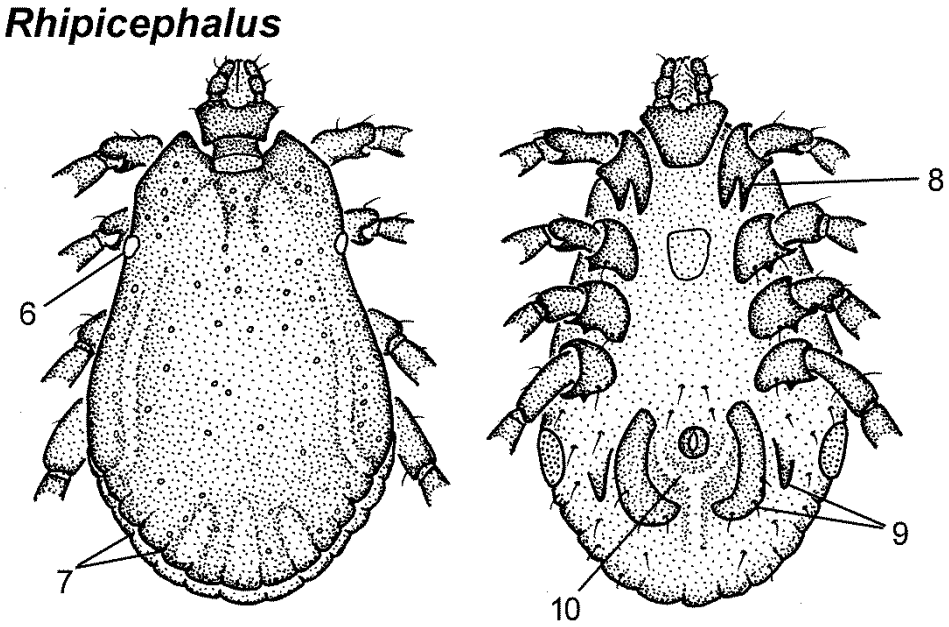


Characters: female dorsal. 1- Medium size ticks, body and mouthparts from 3mm to 6mm long; colored brown. 2- Mouthparts are same length as the basis capituli. 3- Basis capituli has extended lateral margins, making a hexagonal shape. 4- Scutum is plain, without colored patterns (except in two species); often there are distinct ridges and depressions, and varied punctations on the scutum (conscutum of male similar). 5- Legs have no pale rings. 6- Eyes are present and either convex or flat. 7- Posterior body margin has a series of grooves forming a pattern of festoons.

[male *Rhipicephalus* continued]

Rhipicephalus (Ixodidae, Hard-ticks)

[to Contents]



Characters: male left dorsal, right ventral. 6- Eyes are present, either convex or flat. 7- Posterior body margin has a series of grooves forming a pattern of festoons. 8- Coxae 1 have a pair of large spurs. 9- Males have a large sclerotized plates aligned with anus. 10- Anal groove is posterior to the anus in both sexes.

Hosts: Cattle, sheep, goats, horses, dogs, wild bovids, and many other species of mammal are typical hosts for these ticks. Cattle will often maintain all stages of *Rhipicephalus appendiculatus* (Brown ear-tick). Dogs similarly maintain all stages of *R. sanguineus* (Tropical dog-tick). Most rhipicepalids have three-host life-cycles, but several such as *R. evertsi* (Red-legged tick) have a two-host life-cycle.[19]

Signs: These ticks cause irritation, inflammation, pruritus, and biting-stress Also *R. evertsi* may cause toxemia in lambs.

Disease: Reduction in live weight gain of cattle occurs when large infestations of *R. appendiculatus* are on cattle.[20] The boophilid species transmit to cattle and sheep *Babesia* species of protozoa leading to Babesiosis, and *Anaplasma* species of bacteria leading to Anaplasmosis. *Rhipicephalus appendiculatus* transmits between cattle the protozoan *Theileria parva* leading to East coast fever; this tick also transmits between sheep the virus causing Nairobi sheep disease. *Rhipicephalus sanguineus* transmits between dogs the bacterium *Ehrlichia canis* leading to Canine ehrlichiosis.[21]

Distribution: *Rhipicephalus* species are mainly confined to Africa. However, *R. sanguineus* has become distributed wherever domestic dogs inhabit warm regions; and in sheltered habitat of human housing or dog kennels will flourish between latitudes 50^{o} north to 35^{o} south.[22]

References

1. Sonenshine, D.E. (2014) *Biology of Ticks* (vols 1 and 2). New York: Oxford University Press. ISBN 978-0-19-974405-3.
2. Bowman, A. S., Nuttall, P. A. (2008) *Ticks: Biology, Disease and Control*. Cambridge University Press, Cambridge, ISBN 978-0-521-86761-0.
3. Fivaz, B., Petney, T., Horak I. (1992) *Tick Vector Biology: Medical and Veterinary Aspects*. Springer-Verlag, Heidelberg, ISBN 3-540-54045-8.
4. Latif, A.A. (2013) *Illustrated Guide to Identification of African Tick Species*. Agricultural Research Council, Pretoria. ISBN 978-0-9922220-5-5.
5. Slamon, M. & Tarres-Call, J. (eds) (2013) *Ticks and Tick-borne Diseases: Geographical Distribution and Control Strategies in the Euro-Asia Region*. CABI, Wallingford. ISBN 978-1-84593-853-6.
6. Spickett, A.M. (2013) *Ixodid Ticks of Major Economic Importance and their Distribution in South Africa*. Pretoria, Agri Connect (Pty).
7. Bekker, C. P., de Vos, S., et al. (2002) Simultaneous detection of *Anaplasma* and *Ehrlichia* species in ruminants and detection of *Ehrlichia ruminantium* in *Amblyomma variegatum* ticks by reverse line blot hybridization. Veterinary Microbiology, 89: 223-238.
8. Gregson, J. D. (1958) Host susceptibility to paralysis by the tick *Dermacentor andersoni* Stiles (Acarina: Ixodidae). The Canadian Entomologist, 90: 421-424.
9. Felz, M. W., Smith, C. D., Swift, T. R. (2000) A six year old girl with tick paralysis. New England Journal of Medicine, 342: 90-94.
10. Bishopp, F.C. (1938) The American dog tick, eastern carrier of Rocky Mountain spotted fever. Washington D.C., Circular 478, United States Department of Agriculture.
11. Kim, C. M., et al. (2003) Identification of *Ehrlichia chaffeensis, Anaplasma phagocytophilum*, and *A. bovis* in *Haemaphysalis longicornis* and *Ixodes persulcatus* ticks from Korea. Vector Borne and Zoonotic Diseases, 3: 17-26.
12. Geevarghese, G., Mishra, A.C. (2011) *Haemaphysalis* Ticks of India, Amsterdam, Elsevier, ISNB 978-0-12-387811-3.
13. Gonzalez, J. P., et al. (1992) Sexual and transovarian transmission of Crimean Congo haemorrhagic fever virus in *Hyalomma truncatum* ticks. Research in Virology, 143: 23-28.
14. Geeverghese, G. & Dhanda, V. (1987) The Indian *Hyalomma* Ticks. New Delhi, Indian Council of Agricultural Research.
15. Spielman, A., et al. (1985) Ecology of *Ixodes dammini* borne human babesiosis and Lyme disease. Annual Review of Entomology, 30: 439-460.
16. Horak, I.G., et al. (1986) Parasites of domestic and wild animals in South Africa. XX. Arthropod parasites of the Cape Mountain Zebra. Onderstepoort Journal of Veterinary Research, 53: 127-152.
17. Howell C.J., et al. (1978) *Ticks, Mites and Insects Infesting Domestic Animals in South Africa*. Republic of South Africa Department of Agricultural Technical Services, Science Bulletin 393, Pretoria.

[to Contents]

18. Barker S.C. & Murrell, A. (2008) Systematics and evolution of ticks with a list of valid genus and species names. In: Bowman A.S. & Nuttall P.A. [As above, pgs 1-39]
19. Walker, J.B., et al. (1978) *Notes on the Ticks of Botswana*. Eschborn, Germany, GTZ. ISBN 3-88085-052-6.
20. Norval, R.A.I., et al. (1997) The effects of the brown ear tick, *Rhipicephalus appendiculatus*, on milk production of Sanga cattle. Medical and Veterinary Entomology, 11: 148-154.
21. Young, A.S., et al. (1986) Maintenance of *Theileria parva parva* infection in an endemic area of Kenya. Parasitology, 93: 9-16.
22. Burlini, L., et al. (2010) Molecular dissimilarities of *Rhipicephalus sanguineus* (Acari: Ixodidae) in Brazil and its relation with samples throughout the world: is there a geographical pattern. Experimental and Applied Acarology, 50: 361-374.

– End of book –