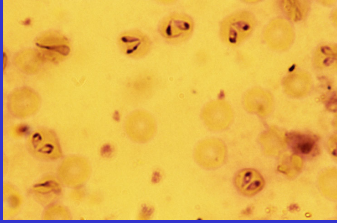


BioMedical Parasitology

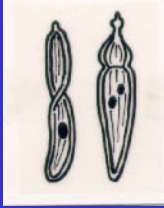

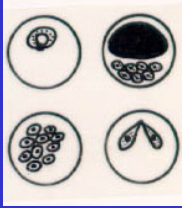
Protozoa piroplasms



Prof Peter O'Donoghue

1





APICOMPLEXA

Gregarinidea (modified conoid) (large extracell. gamonts)	Coccidea (conoid complete) (small intracell. gamonts)	Haematozoa (conoid absent) (motile kinete)
		
gregarines	coccidia	haemosporidia/piroplasms

4


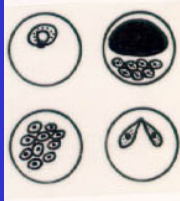
PROTOZOA

65,000 species
(31,250 extant + 33,750 extinct)

flagellates	amoebae	sporozoa	ciliates
			
6,900 species	11,550 species	5,600 species	7,200 species
5,100 free-living 1,800 parasitic	11,300 free-living 250 parasitic	all parasitic	4,700 free-living 2,500 parasitic




2

APICOMPLEXA

Coccidea (conoid complete) (small intracellular gamonts)	Haematozoa (conoid absent) (motile kinete)
	
coccidia	haemosporidia/piroplasms



5

SPOROZOA

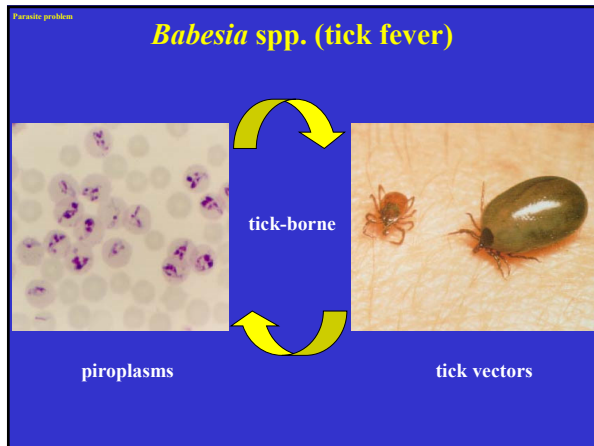
Apicomplexa (apical complex) (oocysts)	Microspora (unicellular) (spores)	Myxozoa (multicellular) (spores)
		
All parasitic		

3

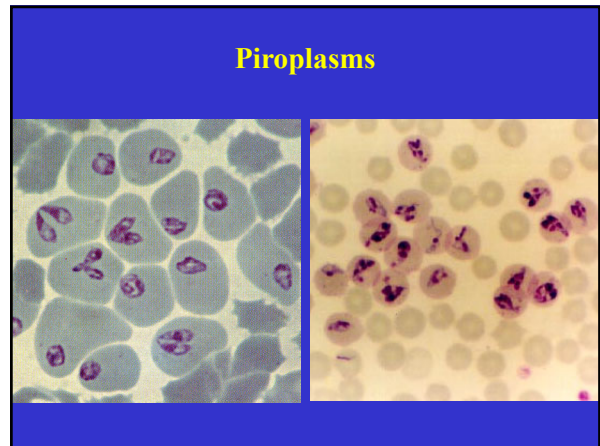
HAEMATOOZOA

Haemosporidia <ul style="list-style-type: none"> • blood spores • malaria • insect vectors 	Piroplasms <ul style="list-style-type: none"> • pear-shaped bodies • tick fevers • tick vectors
 <div style="display: flex; flex-direction: column; justify-content: space-around; margin-left: 10px;"> <p><i>Plasmodium</i></p> <p><i>Haemoproteus</i></p> <p><i>Leucocytozoon</i></p> </div>	 <div style="display: flex; flex-direction: column; justify-content: space-around; margin-left: 10px;"> <p><i>Babesia</i></p> <p><i>Theileria</i></p> </div>

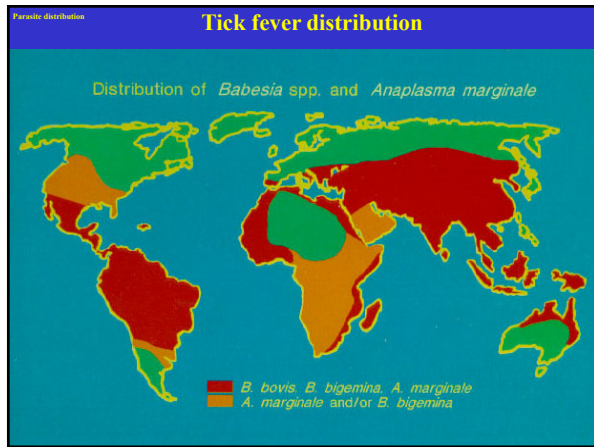
6



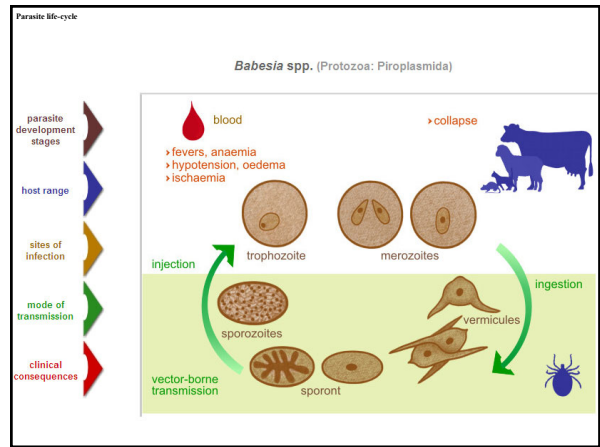
7



10



8



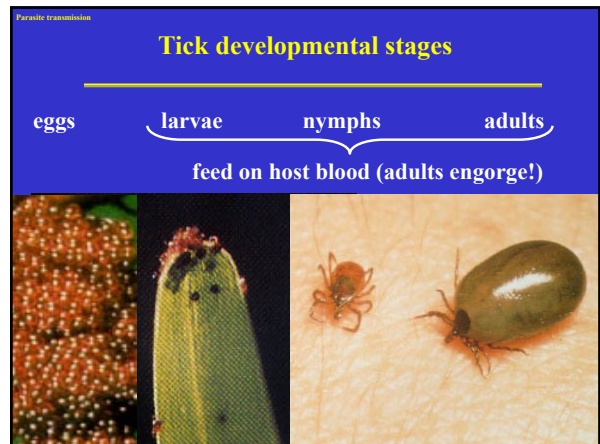
11

Parasite biodiversity

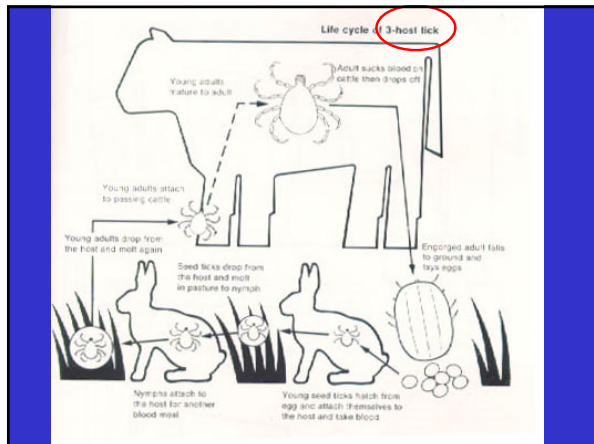
Host distribution

Parasite	Vert. host	Invertebrate vector
<i>B. bovis</i>	cattle, deer	<i>Ixodes</i> , <i>Boophilus</i> , <i>Rhipicephalus</i>
<i>B. bigemina</i>	cattle, deer	<i>Boophilus</i> , <i>Haemaphysalis</i> , <i>Rhipicephalus</i>
<i>B. divergens</i>	cattle	<i>Ixodes</i>
<i>B. major</i>	cattle	<i>Boophilus</i>
<i>B. caballi</i>	horse	<i>Dermacentor</i> , <i>Hyalomma</i> , <i>Rhipicephalus</i>
<i>B. ovis</i>	sheep, goats	<i>Rhipicephalus</i> , <i>Ixodes</i>
<i>B. motasi</i>	sheep, goats	<i>Rhipicephalus</i> , <i>Haemaphysalis</i> , <i>Dermacentor</i>
<i>B. trautmanni</i>	pig	<i>Rhipicephalus</i>
<i>B. canis</i>	canids	<i>Rhipicephalus</i> , <i>Dermacentor</i> , <i>Haemaphysalis</i>
<i>B. gibsoni</i>	canids	<i>Rhipicephalus</i> , <i>Haemaphysalis</i>
<i>B. felis</i>	cat/lion/leopard	<i>Haemaphysalis</i>
<i>B. microti</i>	rodents	<i>Ixodes</i>
<i>B. rodhaini</i>	rodents	unknown

9



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Parasite transmission

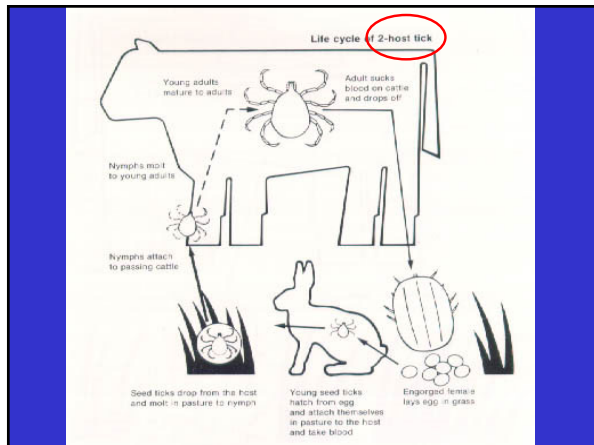
Transmission enigma

How can a one-host tick act as a vector if it never leaves its host?

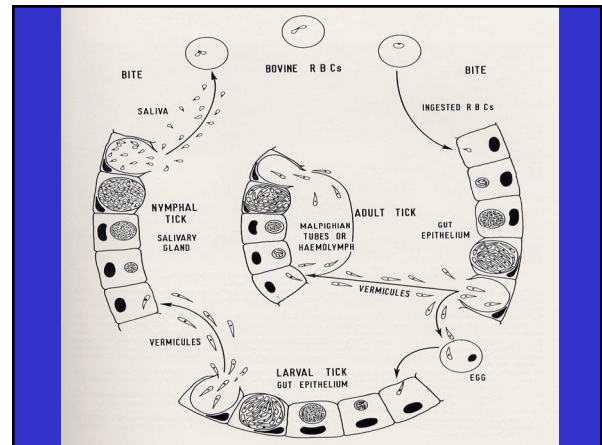
- trans-stadial transmission (larva - nymph - adult)
- trans-ovarian transmission (female - eggs)



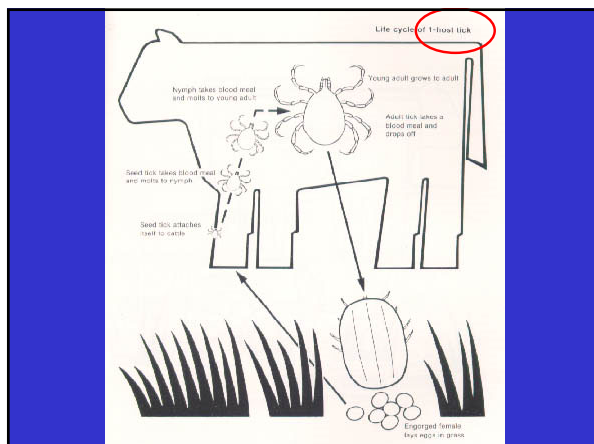
16



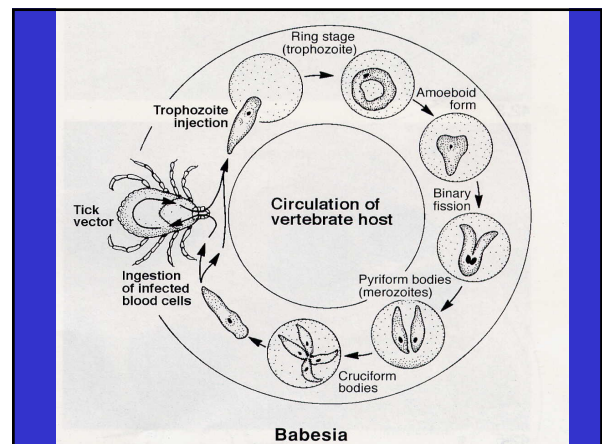
14



17



15

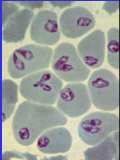


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Parasite pathogenicity

Disease

- intravascular haemolysis (cell rupture)
- release of pharmacologically active agents (e.g. proteolytic enzymes)
 - affect microcirculation (vasodilatation, increased permeability) leading to hypotension and oedema
 - affect blood (viscosity, coagulation, cytoadherence) leading to ischaemia (congestion and degenerative changes in tissues/organs)



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Parasite management

Immunological control

In endemic areas, young animals develop infection-immunity (premunition)

basis of management through:

- premunization (chemoimmunization)
- vaccination
 - attenuated strains
 - subunit vaccines

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Parasite pathogenicity

Bovine babesiosis

- *B. bovis* (*B. argentina*), *B. bigemina*, *B. divergens* cause ‘tick fevers’
 - fever, anorexia, listlessness
 - anaemia, haemoglobinuria (redwater), jaundice
 - diarrhoea, abortion, cerebral signs
 - muscle tremors, wasting
 - coma, death





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Parasite management

Tick fever (*Babesia*) vaccines

- QDPI pioneers for live vaccines (mild)
- chilled/cryopreserved strains of *B. bovis*, *B. bigemina*
- pretreat with acaricides, inject vaccine s/c or i/m
- vaccine failure due to reversion, treat with imizol

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Parasite management

Treatment

babesiocidal chemotherapy

- old-timer drugs (problems with adverse effects, with-holding periods, timing and dosage)
- small species not eradicated (sequestration)
- chemoprophylaxis (moderate infections)

acaricidal chemotherapy

- tick control (susceptibility/resistance issues)

genetic resistance

- *Babesia* and/or tick resistant breeds

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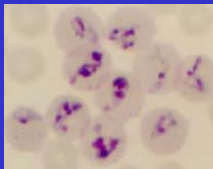
Parasite management

Tick fever (*Babesia*) vaccines

Molecular vaccines

- SBP1: spherical body protein
- RAP-1: rhoptry-associated protein
- MSA-1: 42kDa major surface antigen
- MSA-2: 44kDa major surface antigen

• all induce CD4 response, IFN- γ production and give partial protection



24

Parasite biodiversity

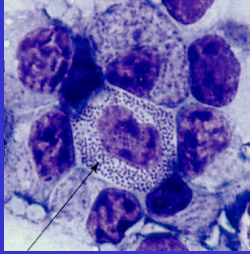
Human babesiosis

- *B. microti* in northeastern USA
- *B. divergens* in Europe
- severe and fatal in asplenic individuals
- 10-20 days incubation after tick bite
- fulminant febrile haemolytic disease - general malaise, then fever, shaking chills, sweating, arthralgias, myalgias, fatigue, weakness
- variable parasitaemia (0-80%)
- occasional hepatosplenomegaly, jaundice
- chemotherapy (clindamycin + quinine)

25

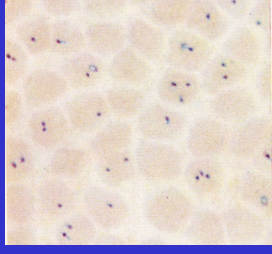
Theileria spp. (tick fever)

leucocytes infected first



merozoites in schizont

then erythrocytes




trophozoites/merozoites

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Parasite problem

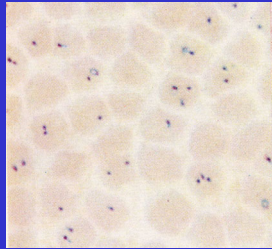
Theileria spp. (East Coast fever)

leucocytes infected first



merozoites in schizont

then erythrocytes



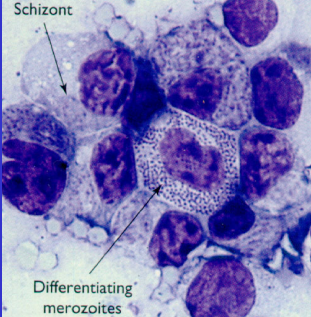
trophozoites/merozoites

26

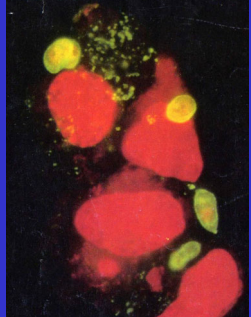
Parasite morphology

Macroschizonts

Schizont



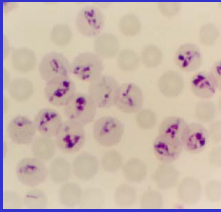
Differentiating merozoites




massive amplification in host cells
(including clonal expansion of infected host cells)

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Theileria spp. (tick fever)

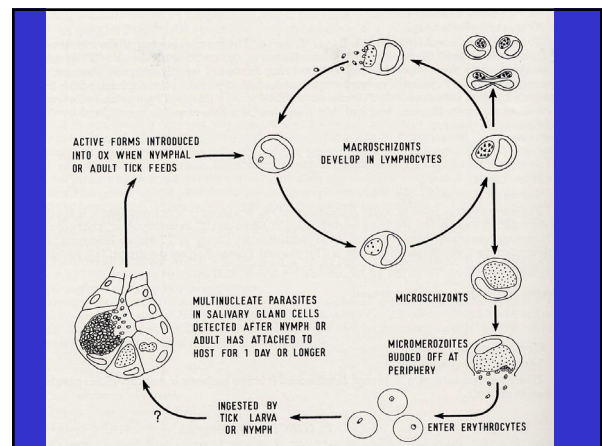


tick-borne

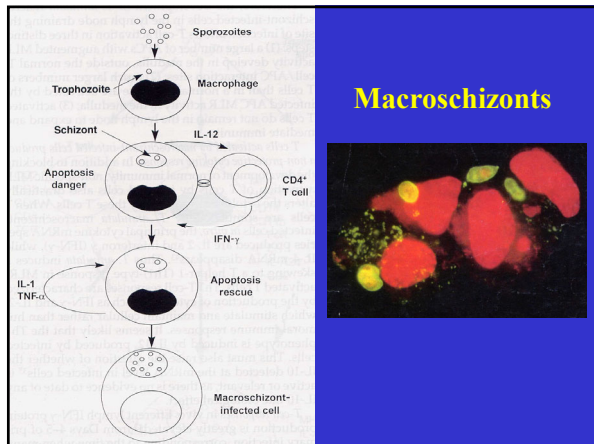


1-host, 2-host, 3-host ticks
trans-stadial (larva - nymph - adult)

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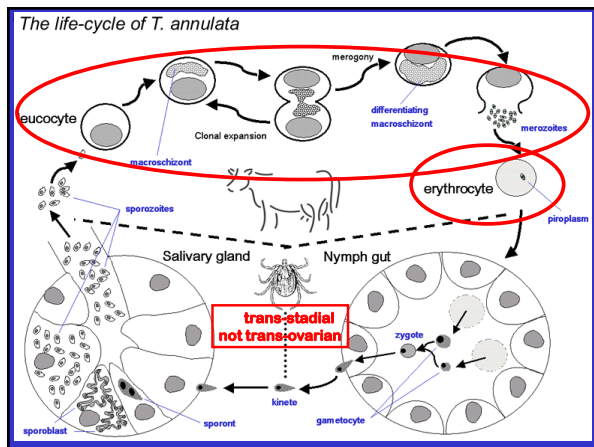


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Disease

- obligative intraerythrocytic parasite
- pathology attributable to intraleucocyte stages (rather than lysis or sequestration of erythrocytes)
- parasitised cells undergo clonal expansion
- lymphadenopathy
- immunological perturbations

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Bovine theileriosis

- primarily in East and South Africa
- *T. parva parva* and *T. parva lawrencei* cause East Coast fever and Corridor disease, respectively
- *T. annulata* causes Mediterranean Coast fever
- animals introduced into enzootic regions rarely survive
- disease characterized by panleucopenia, high fever, lymphadenopathy, severe pulmonary oedema, wasting

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Haematophagous vectors

Parasite	Vert. host	Invertebrate vector
<i>T. parva</i>	cattle, buffalo	<i>Rhipicephalus</i> , <i>Hyalomma</i>
<i>T. annulata</i>	cattle, buffalo	<i>Hyalomma</i>
<i>T. mutans</i>	cattle	<i>Amblyomma</i>
<i>T. sergenti</i> (<i>T. orientalis</i>)	cattle, buffalo	<i>Haemaphysalis</i>
<i>T. hirci</i>	sheep, goats	<i>Rhipicephalus</i>
<i>T. ovis</i>	sheep, goats	<i>Rhipicephalus</i>
<i>T. equi</i>	horse, donkey	<i>Dermacentor</i> , <i>Hyalomma</i> , <i>Rhipicephalus</i>

33

Treatment

babesiocidal chemotherapy

- old-timer drugs (problems with adverse effects, with-holding periods, timing and dosage)
- small species not eradicated (sequestration)
- chemoprophylaxis (moderate infections)

acaricidal chemotherapy

- tick control (susceptibility/resistance issues)

genetic resistance

- *Babesia* and/or tick resistant breeds

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Parasite treatment

Anti-protozoals (piroplasms)

<u><i>Babesia</i></u>	
azonaphthalene dyes	- trypan blue
acridine derivatives	- acriflavine
diamidines	- amicarbalide, imidocarb
	- phenamidine, pentamidine
aminoquinolines	- primaquine
macrolide antibiotics	- clindamycin
<u><i>Theileria</i></u>	
hydroxynaphthoquinone	- menotone, parvaquone
quinazolinone	- halofuginone
Both	
tetracyclines	- oxytetracycline, chlortetracycline

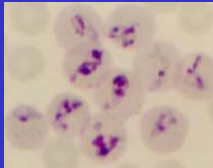
37

Tick fever (*Babesia*) vaccines

Molecular vaccines

- SBP1: spherical body protein
- RAP-1: rhoptry-associated protein
- MSA-1: 42kDa major surface antigen
- MSA-2: 44kDa major surface antigen

- all induce CD4 response, IFN- γ production and give partial protection



40

Immunological control

In endemic areas, young animals develop infection-immunity (premunity)

basis of management through:

- premunization (chemoimmunization)
- vaccination
 - attenuated strains
 - subunit vaccines

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Summary

Babesia

- red cell parasite
- tick fever of domestic livestock
- occasional tick-borne zoonosis
- treatment difficult


Theileria

- white then red cell parasite
- tick fever of herbivores

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Tick fever (*Babesia*) vaccines

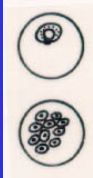

- QDPI pioneers for live vaccines (mild)
- chilled/cryopreserved strains of *B. bovis*, *B. bigemina*
- pretreat with acaricides, inject vaccine s/c or i/m
- vaccine failure due to reversion, treat with imizol



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Parasite assembly

HAEMATOOZA

<h3>Haemosporidia</h3> <ul style="list-style-type: none"> • blood spores • malaria • insect vectors  <p><i>Plasmodium</i> <i>Haemoproteus</i> <i>Leucocytozoon</i></p>	<h3>Piroplasms</h3> <ul style="list-style-type: none"> • pear-shaped bodies • tick fevers • tick vectors  <p><i>Babesia</i> <i>Theileria</i></p>
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