### PLASMODIUM

<table>
<thead>
<tr>
<th>Animal Group(s) Affected</th>
<th>Transmission</th>
<th>Clinical Signs</th>
<th>Severity</th>
<th>Treatment</th>
<th>Prevention and Control</th>
<th>Zoonotic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reptiles, birds – especially penguins, and some mammals, including non-human primates and humans</td>
<td>Mosquitoes of different genera; in reptiles, also other biting flies</td>
<td>Lethargy; anorexia; minor to severe anemia; neurologic signs; paralysis</td>
<td>Typically of low virulence in adapted hosts; mild to severe – possibly fatal – disease in non-adapted hosts</td>
<td>Various antimalarial drugs can be used but are unlikely to eliminate infection at tissue stage; resulting in relapses of parasitemia</td>
<td>Vector control and mosquito proof enclosures</td>
<td>Generally no; in endemic areas, primates can act as a reservoir for humans</td>
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</tbody>
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**Fact Sheet Reviewed by:** Sam Telford Jr.; Arnaud Van Wettere

**Susceptible animal groups:** The parasite is reported in birds of the majority of avian orders. Species that have been relocated from habitats without vector or parasite, or in areas where the vector or parasite have been introduced are especially vulnerable, e.g. penguins, other captive Arctic or Antarctic species, species from Hawaii or other islands.

Infection of mammals is most common in tropical countries; diversity is greatest in Africa, where *Plasmodium* parasites have been reported in primates, rodents, ungulates and bats. One report in wild and captive capybaras in South America has been documented. Humans and non-human primates are infected mainly in tropical Africa, Asia and South America.

Reptiles have been seen infected mainly in tropical countries – primarily lizards, some snakes, and reported anecdotally in tortoises, but has not been reported in turtles or crocodiles.

**Causative organism:** *Plasmodium* spp. (Plasmodiidae, Haemosporida) >200 species.

**Zoonotic potential:** No zoonotic risk exists from avian or reptilian species. Although no evidence of zoonotic risk from non-human primate species, primates can carry the same species that infect humans, so reservoir exists.

**Distribution:** Worldwide, except Antarctica due to absence of mosquitoes and low temperature.

**Incubation period:** Avian – usually 5-7 days.

**Clinical signs:** Cases in most species of adapted hosts are often of low virulence. Importantly, the same lineages of *Plasmodium* sp. cause diseases of markedly different severity in different avian hosts that should be taken in consideration in conservation projects. Susceptible non-adapted avian species (e.g. penguins and some endemic Hawaiian birds) present lethargy, dyspnea, anorexia, vomiting, ruffled feathers, anemia where hematocrits may fall by more than 50% and regenerative hemolytic anemia is observed. Biliverdinuria may occur. Partial or total paralysis and convulsions can present terminally.

**Post mortem, gross, or histologic findings:**

**Avian:** Blood and reticuloendothelial system – hemolysis, splenomegaly, hepatomegaly, and pulmonary edema. Macrophages, lymphocytes and plasma infiltrate in liver and spleen. Exoerythrocytic meronts in endothelial cells with possible blockage of brain and lung capillaries. Hemozoin pigment in Kupffer cells and splenic macrophages.

**Primates:** virulence of different species and strains markedly vary in different hosts. Macroscopic pathology of the brain and endocardium might show hemorrhages, and the liver and spleen often are enlarged.
**Microscopic pathology** usually shows sequestration of pigmented parasitized red blood cells in the vessels of the cerebrum, cerebellum, heart, kidney and other organs. The spleen and liver contains abundant pigment containing macrophages and parasitized red blood cells. During acute infections, the kidney often has evidence of tubular necrosis.

**Diagnosis:** Identification of intracellular red blood cell parasite on a smear, but difficult to detect low intensity chronic infections by microscopy; gold standard – Giemsa stained blood smear – erythrocytic meronts and gametocytes with pigment granules. PCR is more sensitive but may still not identify low level parasitemias and often does not read co-infections; small subunit ribosomal ribonucleic acid and mitochondrial cytochrome b genes are definitive targets for malarial parasite ID and used to determine genetic relationships. Immunoblotting can be used to ID antibodies to *Plasmodium* but only to the level of parasite genus. ELISA available for *P. relictum* in penguins.

**Material required for laboratory analysis:** Giemsa stained blood films (microscopy) and whole blood or tissue (i.e. liver and/or spleen) (PCR) are most often used.

**Relevant diagnostic laboratories:** Any laboratory performing complete blood counts is capable of diagnosis *Plasmodium* spp. on blood smears. DNA testing is not widely performed commercially at this time, but is available in many research laboratories that manage wildlife parasites.

**Treatment:**
- Avian – Chloroquine phosphate, primaquine phosphate, pyrimethamine-sulfadoxine combinations, mefloquine, and atovaquone - proguanil hydrochloride – canaries, penguins, raptors and wild passerines.
- Sulfamonomethoxine – suppresses parasitemia but does not protect from mortality if given after circulating parasites are present, sulfachloropyrazine – reduces mortality but has no effect of parasitemia. Halofuginone – delays parasitemia but only minor suppression of it – turkeys. Mefloquine, and atovaquone - proguanil hydrochloride are highly efficient for blood stages, but does not affect exoerythrocytic (tissue) stages.
- Primates - drugs which are used for human malaria treatment can be used for treatment of malaria in primates (chloroquine phosphate, quinine sulfate plus doxycycline or malarone, and other drugs).

**Prevention and control:** Housing susceptible species indoors. Vector (mosquito) control. Prophylactic treatment of highly susceptible species can be considered. Vaccines development is under trial. Preventive treatment for primates has not been used extensively.

**Suggested disinfectant for housing facilities:** Disinfection is not appropriate for this disease.

**Notification:** None.

**Measures required under the Animal Disease Surveillance Plan:** None.

**Measures required for introducing animals to infected animal:** Isolate infected animals with vector control to prevent spread to susceptible animals.

**Conditions for restoring disease-free status after an outbreak:** Difficult or impossible as wildlife acts as a reservoir.

**Experts who may be consulted:**
- Centers for Disease Control and Prevention
- Center for Global Health, Division of Parasitic Diseases and Malaria
  - 1600 Clifton Road
  - Mailstop A-06
  - Atlanta, Georgia 30333
  - 770-488-7788 or 855-856-4713 (toll-free)
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  - malaria@cdc.gov
www.cdc.gov/malaria

References: