**Supplementary Material**

Macro and microparasite in worldwide penguins host populations: a global overview of its health state

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Table S1. Macro and microparasites reported in the 18 penguin species in wild.

Reference List S1. References from parasites and pathogens listed in Table S1.

**Table I.** Macro and microparasites reported in the 18 penguin species in wild. EN= Endangered, LC= Least Concern, NT= Near Threatened, VU= Vulnerable. **A**= Antibodies, **I**= Isolated. Numbers in brackets refers to references in table foot.

|  |  |  |  |
| --- | --- | --- | --- |
| Species |  | Macroparasites | Microparasites |
| Population status | Helminths | Arthropods | Bacteria | Protozoa |
| **Yellow-eyed penguin *Megadyptes antipodes*** |  | *Contracaecum eudyptulae* (115) | *Austrogoniodes concii* (13; 166) | *Corynebacterium amycolatum* **I** (4) | Coccidiasp. (3;171) |
|  | *Contracaecum rudolphii*(19) | *Austrogoniodes* sp. (166) | *Corynebacterium* sp. **I** (3) | *Eimeria* sp. (171; 120; 119) |
|  | *Contracaecum* sp. (3; 171) | *Austrogoniodes vanalphenae* (12; 13) | *Staphylococcus alirelis* **I** (87) | *Leucocytozoon* sp. (10; 99; 103; 123) |
| Decreasing (EN) | Unidentified acanthocephalan (172) | *Ixodes auritulus* (22; 57; 100) |  | *Plasmodium elongatum* (108) |
|  |  | *Ixodes eudyptidis* (100) |  | *Plasmodium relictum* (72; 127) |
|  |  | *Ixodes uriae* (22; 61) |  | *Plasmodium relictum* **A** (94) |
|  |  | *Parapsyllus longicornis* (151) |  | *Plasmodium* sp. (3; 119) |
| **Little Penguin *Eudyptula minor*** | Stable (LC) | *Andracantha sigma* (168; 18) | *Austrogoniodes waterstoni* (13; 44; 95; 121; 166) | *Campylobacter* sp. **I** (52) | *Babesia* sp. (192) |
| *Anisakis* sp*.* (114) | *Eulaelaps* sp. (22; 201) |  | Coccidia sp. (36; 97; 154) |
| *Bolbosoma balaenae* (18) | *Haemolaelaps* ( *= Androlaelaps*) *pachyptilae* (22) |  | *Haemoproteus* sp. (35; 33) |
| *Capillaria* sp. (144; 18) | *Ingrassia eudyptula* (147) |  | *Plasmodium elongatum* (5) |
| *Contracaecum eudyptulae* (114; 18) | *Ixodes auritulus* (22; 57) |  | *Plasmodium relictum* **A** (94; 191) |
| *Contracaecum spiculigerum* (142; 154) | *Ixodes eudyptidis* (57;151; 191) |  | *Toxoplasma gondii* (140; 33) |
| *Contracaecum* spp. (36; 97) | *Ixodes kohlsi* (11; 57) |  | *Trypanosoma eudyptulae* (116) |
| *Corynosoma* sp. (142; 144; 170) | *Ixodes percavatus* (57) |  |  |
| *Echinostoma* sp. (49) | *Ixodes uriae* (22; 100; 151) |  |  |
| *Galactosomum angelae* (154; 165) | *Liponyssoides eudyptulae* (22) |  |  |
| *Galactosomum* sp. (144) | *Ornithodoros* (*Alectorobius*) *capensis* (126) |  |  |
| *Galactosomum otepotiense* (18; 170) | *Parapsyllus jacksoni* (22; 183) |  |  |
| *Mawsonotrema eudyptulae* (8; 97; 142) | *Parapsyllus longicornis* (151; 191) |  |  |
| *Renicola* sp. (142; 154) | *Psylloglyphus parapsyllus* (70) |  |  |
| *Stegophorus macronectes* (18; 19) |  |  |  |
| *Tetrabothrius lutzi* (170; 18) |  |  |  |
| *Tetrabothrius* sp. (142; 144; 154; 18) |  |  |  |
| Unidentified Filaroidea (142) |  |  |  |
| Unidentified Tetrabothridae (142) |  |  |  |
| **King Penguin *Aptenodytes patagonicus*** |  | *Contracaecum heardi* (73; 141) | *Austrogoniodes* sp. (196) | *Borrelia burgdorferi* **I** (85; 180) | *Babesia peircei* (163) |
| Increasing (LC) | *Contracaecum* sp. (141) | *Austrogoniodes brevipes* (13; 44; 47; 121; 151) | *Campylobacter jejuni* **I** (40) | *Babesia* sp. (161) |
| *Tetrabothrius pauliani* (170) | *Austrogoniodes mawsoni* (98) | *Campylobacter* sp. **I** (52) | *Plasmodium relictum* (72) |
| *Tetrabothrius wrightii* (73) | *Ixodes uriae* (63; 64; 78; 84; 85; 136; 137; 151; 152; 161; 180) | *Rickettsia -* like (161) | *Plasmodium relictum* **A** (94) |
| *Tetrameres wetzeli* (73) | *Nesiotinus demersus* (13; 47; 157; 166) | *Rickettsiella* **I** (64) |  |
|  | *Nesiotinus* sp. (196) |  |  |
| **Emperor Penguin *Aptenodytes forsteri*** |  | *Contracaecum osculatum* (79) | *Austrogoniodes mawsoni* (13; 44; 46; 47; 121; 166) | *Chlamydia* sp. **A** (149) |  |
| Decreasing (NT) | *Diphyllobotrhium* sp. (124) | *Austrogoniodes* sp. (196) |  |  |
| *Parorchites zederi* (79; 124; 170) |  |  |  |
| *Stegophorus macronectes* (79) |  |  |  |
| *Tetrabothrius* sp. (79; 124) |  |  |  |
| *Tetrabothrius wrightii* (170) |  |  |  |
| *Tetrameres* sp. (79) |  |  |  |
| **Chinstrap Penguin *Pygoscelis antarctica*** |  | *Corynosoma pseudohamanni* (58) | *Austrogoniodes gressitti* (44; 47; 151; 92) | *Alcaligenes faecalis* **I** (117) | *Babesia* sp. (148) |
| Decreasing (LC) | *Corynosoma* sp.(198) | *Austrogoniodes macquariensis* (44; 47) | *Campylobacter lari* **I** (81; 113) | *Eimeria pygosceli* (88) |
| *Parorchites zederi* (111; 198; 92) | *Austrogoniodes* sp. (196) | *Campylobacter subantarcticus* **I** (113) | *Isospora* sp. (88) |
| *Stegophorus macronectes* (198; 92) | *Ixodes uriae* (14; 143; 148; 150; 202; 92) | *Edwardsiella tarda* **I** (132) | *Sarcocystis* sp. (110) |
| *Tetrabothrius joubini* (86; 111) |  | *Escherichia coli* **I** (117) |  |
| *Tetrabothrius paulini* (7; 86; 198; 92) |  | *Pasteurella multocida* **l** (48) |  |
|  |  | *Staphylococcus saprophyticus* **I** (117) |  |
|  |  | *Streptococcus faecalis* **I** (117) |  |
| **Adelie Penguin *Pygoscelis adeliae*** |  | *Parorchites zederi* (43; 56; 170; 188) | *Austrogoniodes antarcticus* (13; 44; 46; 47; 98; 121; 151; 166) | *Campylobacter lari* **I** (81; 130) | Coccidiansp. (146) |
| Increasing (LC) | *Stegophorus macronectes* (56; 207; 188) | *Austrogoniodes bifasciatus* (44; 47) | *Clostridium cadaveris* **I** (153) | *Cryptosporidium* sp. (77) |
| *Tetrabothrius pauliani* (43) | *Austrogoniodes* sp. (196) | *Clostridium sporogenes* **I** (153) | *Eimeria pygosceli* (88) |
| *Tetrabothrius* sp. (56) | *Ixodes uriae* (14; 20; 129; 143; 202) | *Edwardsiella tarda* **I** (132) | *Isospora* sp. (88) |
| *Tetrameres* sp. (56) | *Rhinonyssus scheili* (193; 202) | *Escherichia coli* **I** (153) | *Sarcocystis* sp. (110) |
|  |  | *Pasteurella multocida* **l** (48; 131) |  |
|  |  | *Salmonella enterica* **I** (197) |  |
|  |  | *Salmonella pullorum***A** (159) |  |
|  |  | *Salmonella* sp. **I** (155) |  |
|  |  | *Staphylococcus* sp. **I** (153) |  |
| **Gentoo Penguin *Pygoscelis papua*** | Stable (LC) | *Contracaecum heardi* (114; 141) | *Austrogoniodes gressitti* (13; 44; 46; 47; 91; 151) | *Alcaligenes faecalis* (117) | *Cryptosporidium* sp. (76) |
| *Contracaecum* sp. (75; 76) | *Austrogoniodes keleri* (44; 47) | *Bacillus cereus* (117) | *Eimeria pygosceli* (88) |
| *Corynosoma bullosum* (55; 104) | *Austrogoniodes macquariensis* (44; 47) | *Campylobacter lari* **I** (40; 81; 113) | *Isospora* sp. (88) |
| *Corynosoma hamanni* (55) | *Austrogoniodes* sp. (196) | *Campylobacter volucris* **I** (81; 113) | *Plasmodium relictum* **A** (94) |
| *Corynosoma schackletoni* (55; 91; 104) | *Ayersacarus tilbrooki* (107) | *Chlamydia* sp. **A** (149) | *Sarcocystis* sp. (110) |
| *Diphyllobotrhium* sp. (91) | *Gamasellus antarcticus* (190) | *Edwardsiella tarda* **I** (25; 132) |  |
| *Parorchites zederi* (43; 55; 86; 91) | *Gamasolaelaps arenosus* (107) | *Enterococcus faecalis* (139) |  |
| *Stegophorus adeliae* (91) | *Ixodes uriae* (14; 39; 42; 64; 91; 143; 151) | *Mycoplasma synoviae* **A** (159) |  |
| *Stegophorus macronectes* (55; 141) | *Naubates prioni* (157) | *Rickettsia -* like **I** (42) |  |
| *Streptocara* sp. (75) | *Parapsyllus longicornis* (51) | *Rickettsiella* **I** (64) |  |
| *Tetrabothrius pauliani* (170) | *Rhinonyssus scheili* (193) | *Salmonella enteriditis* **I** (59; 156; 158; 173) |  |
| *Tetrabothrius* sp. (75; 76) |  | *Salmonella havana* (158) |  |
| *Tetrameres wetzeli* (55) |  | *Salmonella typhymurium* **I** (59; 158) |  |
| **African Penguin *Spheniscus demersus*** | Decreasing (EN) | *Cardiocephaloides physalis* (106; 171) | *Austrogoniodes demersus* (13; 121; 187) | *Anaplasma* spp. (195) | *Babesia peircei* (65; 206) |
| *Contracaecum variegatum* (69) | *Austrogoniodes strutheus* (45) | *Borrelia* sp. **I** (162; 203; 187) | *Babesia* sp. (17; 31; 162; 187) |
| *Cyathostoma phenisci* (118) | *Ornithodoros* (*Alectorobius*) *capensis* (126; 200; 187; 247) |  | *Cryptosporidium* spp. (109) |
| *Metorchis orientalis* (101) | *Parapsyllus humboldti* (126; 200; 187) |  | *Plasmodium relictum* (17; 31; 72) |
| *Metorchis pinguinicola* (101) | *Rhinonyssus sphenisci* (193) |  | *Plasmodium relictum* **A** (94) |
| *Metorchis tener* (101) |  |  | *Plasmodium* sp. (187) |
| *Metorchis xanthostomus* (101) |  |  |  |
| *Renicola sloanei* (106) |  |  |  |
| **Galapagos Penguin *Spheniscus mendiculus*** | Decreasing (EN) | *Contracaecum* sp. (38) | *Austrogoniodes demersus* (12) | *Clostridium perfringens* (174) | *Entamoeba* sp. (38) |
| *Paronchocerca straeleni* (41) |  |  | *Haemoproteus* sp. (134; 160) |
| Unidentified microfilariae (145; 160; 182) |  |  | *Plasmodium* sp. (133; 160) |
|  |  |  | *Sporozoa* sp. (38) |
| **Humboldt Penguin *Spheniscus humboldti*** | Decreasing (VU) | *Cardiocephaloides physalis* (9; 138) | *Austrogoniodes bifasciatus* (12;13) | *Coxiella -* like (63) | *Haemoproteus* sp. (177) |
| *Contracaecum pelagicum* (9; 89; 205) | *Ornithodoros* (*Alectorobius*) *amblus* (186) |  |  |
| *Contracaecum* sp. (89) | *Ornithodoros* (*Alectorobius*) *spheniscus* (90; 105) |  |  |
| *Cosmocephalus obvelatus* (138) | *Ornithodoros capensis* (63) |  |  |
| *Cyathostoma phenisci* (9) | *Parapsyllus humboldti* (186) |  |  |
| *Dirofilaria immitis* (175) | *Rhinonyssus sphenisci* (185) |  |  |
| *Tetrabothrius eudyptidis* (89) |  |  |  |
| *Tetrabothrius* sp. (89; 138) |  |  |  |
| **Magellanic Penguin *Spheniscus magellanicus*** |  | *Ascaridia* sp. (89) | *Amblyomma parvitarsum* (16) | *Aeromonas* sp. **I** (37) | *Plasmodium relictum* **A** (94) |
| Decreasing (LC) | *Ascocotyle* (*Ascocotyle*) *felippei* (24) | *Austrogoniodes bifasciatus* (13; 121; 122; 189) | *Chlamydia psittaci* **A** (19) | *Sarcocystis falcatula* (2) |
| *Ascocotyle* (*Phagicola*) *longa* (27) | *Austrogoniodes* sp. (122) | *Corynebacterium spheniscorum* **I** (93) | *Toxoplasma gondi* **A** (2) |
| *Ascocotyle* (*Phagicola*)sp. (27) | *Ixodes uriae* (122; 150) | *Escherichia coli* (181) |  |
| *Cardiocephaloides physalis* (24; 27; 54; 60; 74; 89; 135; 164; 167; 189; 206; 1; 68) | *Parapsyllus longicornis* (128) | *Mycoplasma gallisepticum* **I** (15) |  |
| *Cardiocephaloides* sp. (164) | *Parapsyllus magellanicus* (185) | *Salmonella Pullorum* **A** (19) |  |
| *Contracaecum heardi* (89) | *Parapsyllus* sp. (122) | *Salmonella Typhimurium* **A** (19) |  |
| *Contracaecum pelagicum* (26; 34; 54; 66; 80; 164; 167; 176; 189; 68) | *Rhinonyssus sphenisci* (193) | *Vibrio* sp. **I** (37) |  |
| *Contracaecum plagiaticium* (34; 68) |  |  |  |
| *Contracaecum* sp. (69; 164) |  |  |  |
| *Contracaecum spheniscus* (23; 24) |  |  |  |
| *Corynosoma australe* (102) |  |  |  |
| *Corynosoma* sp. (24; 54) |  |  |  |
| *Cosmocephalus obvelatus* (53) |  |  |  |
| *Diomedenema tavaresi* (125) |  |  |  |
| *Mesostephanus odhneri* (27) |  |  |  |
| *Microfilaria* (*Onchocercidae*)(194) |  |  |  |
| *Posthodiplostomum macrocotyle* (27) |  |  |  |
| *Renicola* sp. (112) |  |  |  |
| *Ribeiroia ondatrae* (24) |  |  |  |
| *Schistosomes* (*Schistosomatidae*)sp. (194) |  |  |  |
| *Stephanoprora uruguayensis* (27) |  |  |  |
| *Tetrabothrius eudyptidis* (89) |  |  |  |
| *Tetrabothrius lutzi* (24; 54; 164; 167; 68) |  |  |  |
| *Tetrameres* sp. (199) |  |  |  |
| **Erect-crested Penguin *Eudyptes* *sclateri*** | Decreasing (EN) |  | *Austrogoniodes concii* (44; 166) | *Chlamydia* sp. **A** (149) | *Plasmodium elongatum* (108) |
|  | *Austrogoniodes cristati* (44; 166) |  |  |
|  | *Austrogoniodes hamiltoni* (98; 166) |  |  |
|  | *Austrogoniodes macquariensis* (98) |  |  |
|  | *Austrogoniodes strutheus* (44; 98; 121; 166) |  |  |
|  | *Austrogoniodes waterstoni* (98) |  |  |
|  | *Ixodes uriae* (22; 61; 100) |  |  |
| **Fiordland Penguin *Eudyptes* *pachyrhynchus*** | Decreasing (NT) | *Diomedenema dinarctos* (5; 19; 29) | *Austrogoniodes concii* (13; 44; 47; 95; 166) | *Mycoplasma lipofaciens* (32) | *Leucocytozoon tawaki* (6; 71) |
| *Contracaecum rudolphii* (19) | *Austrogoniodes cristati* (166) |  | *Plasmodium relictum* (127) |
|  | *Austrogoniodes hamiltoni* (44; 47; 98) |  | *Plasmodium elongatum* (108) |
|  | *Austrogoniodes macquariensis* (44; 47) |  | *Sarcocystis* sp. (179) |
|  | *Ixodes eudyptidis* (22; 57; 61) |  |  |
|  | *Ixodes uriae* (22; 61) |  |  |
| **Northern Rockhopper Penguin *Eudyptes moseleyi*** | Decreasing (EN) |  | *Austrogoniodes concii* (96) |  | *Babesia* sp. (163) |
|  | *Austrogoniodes cristati* (96) |  | *Plasmodium* sp. (163) |
|  | *Austrogoniodes* sp. (96) |  |  |
| **Royal Penguin *Eudyptes schlegi*** | Unknow (LC) | *Anisakis* sp. (141) | *Austrogoniodes cristati* (44; 47; 151) |  |  |
| *Parorchites zederi* (170) | *Austrogoniodes hamiltoni* (13; 44; 47; 151) |  |  |
|  | *Austrogoniodes macquariensis* (121; 151) |  |  |
|  | *Austrogoniodes strutheus* (44; 47) |  |  |
|  | *Ixodes uriae* (100; 136; 151; 152) |  |  |
| **Macaroni Penguin *Eudyptes chrysolophus*** | Decreasing (VU) | *Tetrabothrius* sp. (7) | *Austrogoniodes bicornutus* (44; 47; 151) | *Campylobacter jejuni* **I** (28; 40) |  |
|  | *Austrogoniodes concii* (44; 47; 157) | *Campylobacter lari* **I** (40) |  |
|  | *Austrogoniodes cristati* (44; 46; 47; 151; 157; 166) | *Pasteurella multocida* **l** (48) |  |
|  | *Austrogoniodes demersus* (47) | *Rickettsiella* sp. **I** (42; 64) |  |
|  | *Austrogoniodes gressitti* (44; 47) |  |  |
|  | *Austrogoniodes hamiltoni* (44; 151; 157; 166) |  |  |
|  | *Austrogoniodes keleri* (44; 46; 47; 151) |  |  |
|  | *Austrogoniodes macquariensis* (44; 46; 47; 151; 157; 166) |  |  |
|  | *Austrogoniodes* sp. (196; 166) |  |  |
|  | *Ixodes uriae* (21; 30; 42; 64; 78; 151; 202) |  |  |
|  | *Parapsyllus magellanicus* (185) |  |  |
| **Snares Penguin *Eudyptes* *robustus*** | Stable (VU) | *Diomedenema dinarctos* (19) | *Austrogoniodes concii* (13; 166) |  | *Plasmodium relictum* (127) |
|  | *Austrogoniodes cristati* (13; 166) |  |  |
|  | *Austrogoniodes hamiltoni* (157) |  |  |
|  | *Austrogoniodes macquariensis* (157) |  |  |
|  | *Ixodes auritulus* (22; 57; 61) |  |  |
|  | *Ixodes uriae* (22; 62; 151) |  |  |
| **Southern Rockhopper Penguin *Eudyptes chrysocome*** | Decreasing (VU) | *Contracaecum eudyptes* (115) | *Austrogoniodes concii* (44; 47; 151) | *Chlamydia* sp. **A** (149) | *Plasmodium relictum* (72) |
| *Synhaemantus* sp. (122) | *Austrogoniodes cristati* (13; 44; 46; 47; 122; 151; 157; 166) | *Pasteurella multocida* **l** (48; 50) | *Babesia* sp. (163) |
| *Tetrabothrius eudyptidis* (122) | *Austrogoniodes hamiltoni* (44; 47; 121) | *Rickettsiella* sp. **I** (64) |  |
| *Tetrameres wetzeli* (178) | *Austrogoniodes keleri* (13; 44; 46; 47; 122) |  |  |
|  | *Austrogoniodes macquariensis* (13; 44; 46; 47; 121; 122; 151; 157; 166) |  |  |
|  | *Austrogoniodes macquariensis* (166) |  |  |
|  | *Austrogoniodes* sp. (196) |  |  |
|  | *Ingrassia eudyptula* (147) |  |  |
|  | *Ixodes auritulus* (57) |  |  |
|  | *Ixodes uriae* (30; 42; 50; 64; 122; 136; 152) |  |  |
|  | *Parapsyllus heardi* (151; 152) |  |  |
|  | *Parapsyllus longicornis* (151) |  |  |
|  | *Parapsyllus magellanicus* (22; 152; 184; 185) |  |  |
|  | *Parapsyllus* sp. (122) |  |  |

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