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This journal also welcomes more informal articles, brief notes, and anecdotal reports, of interest to our readers.

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Woburn Safari Park contributes to research project in Chile

At the PHVA Workshop following the Conference, funds raised at Woburn Safari Park, Bedfordshire, England, were presented to researchers beginning a study on the use of artificial nest structures for Humboldt penguins in Chile. The study is headed by Mary Jo Willis and Braulio Araya, and will test different designs and materials for suitability in Chilean weather conditions. The artificial burrows are a way to protect Chilean Humboldts from two of their worst terrestrial problems: predators taking eggs and chicks, and heavy spring rains which often flood out nesting penguins.

Concrete artificial nestboxes have been introduced by Rosana Paredes and colleagues at Punta San Juan, Peru, and the penguins have used them with little hesitation. So far the rate of chick fledging in the artificial burrows is equal to that in the most successful natural burrows at the colony.

The funds came from small donations by the public, raised in a project started by Sarah Forsyth, a senior keeper at Woburn.

In their talks to the public, keepers and docents at Woburn described the threatened status of the Humboldt penguin, and how artificial nestboxes might be able to help. Staff made a sample nest-box, and used a display board with pictures taken at Punta San Juan, as part of their presentations. Through their work, and the generosity of the zoo visitors, they raised UK£650 (nearly US$800) in a single season, and this was the money presented to Braulio Araya by Penguin Conservation's editor.

The population of Humboldt penguins (Spheniscus humboldti) in both Peru and Chile is declining. Since the El Niño of 1997/8 the number of penguins at the largest Peruvian colony, Punta San Juan, has dropped by half. While the species has probably dealt with this climate variation for thousands of years, now it suffers other losses from human activities such as overfishing, death by net entanglement, and possible climate change.

Conferences on island ecology

Eradication of Island Invasives: Practical Actions & Results Achieved

An international conference of the Invasive Species Specialist Group of IUCN to be held at the University of Auckland, Auckland, New Zealand from 19 to 23 February 2001.

Papers presented and discussion sessions will be strictly limited to the subject of: “Eradication of invasive species from islands; methods used and the results achieved.” The term ‘island’ may include true islands, natural habitat islands (eg. ponds), remnant and artificial habitat islands (eg. reserves), or new invasions of natural ecosystems where eradication was deemed feasible. Preference will be given to papers which provide detail of the techniques used or of the ecosystem response to the work. Significant learning experiences may include methods which failed.

The conference is planned to run from mid-morning Monday 19 February to mid-day Friday 23 February 2001. All correspondence or from reading their work. Quite a few people told me that they found Penguin Conservation useful, and enjoyable to read; this was very good to hear, and I took note of comments about what sorts of things were most useful so that the journal can better serve the readers and the conservation of penguins.

My trip to the conference was made possible by generous financial support from a number of institutions. Their grants to Penguin Conservation have paid for printing and postage, and miscellaneous expenses such as phone/fax and office/computer costs, so that for the first time there was enough left in the bank to pay for air fare and registration at the International Penguin Conference. Paid subscriptions and contributions from individuals have also been a great help.

I'd like to take this opportunity to thank everyone who has supported Penguin Conservation, and in particular the following institutions:

- Columbus Zoo
- New England Aquarium
- Penguin Conference of Japan
- Tokyo Sea Life Park

There has been a long gap between this issue of Penguin Conservation and the last, which was vol. 12 #2, December 1999. For this I apologize, most particularly to those who had sent in money for new subscriptions and then received nothing. The delay was caused by health problems. Paid subscribers can be assured that their subscription will run for a year's worth of issues (3), or two years' worth for those who have sent in checks for that time period.

If possible, a second issue will appear before the end of the year.

In September I attended the Fourth International Penguin Conference (see article page 2). This was the first one I had attended. It was good to meet, and it was a great day. People I had only known from correspondence or from reading their work. Quite a few people told me that they found Penguin Conservation useful, and enjoyable to read; this was very good to hear, and I took note of comments about what sorts of things were most useful so that the journal can better serve the readers and the conservation of penguins.

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A short report from the Fourth International Penguin Conference

CYNTHIA CHENEY

Nearly a hundred researchers and conservationists gathered for the Fourth International Penguin Conference in La Serena/Coquimbo, Chile, the first week of September.

There were real penguins as well as reports about penguins—at least one person, using binoculars, was able to see penguins from the beach near the hotel. But the conference organizers had provided a much better opportunity, with a trip by bus and boat on Wednesday to circumnavigate an island colony. Fortunately the seas were cooperative on that day, and as the boat went around the island, people saw not only Humboldt penguins but also other seabirds, seals, and sea otters. Terrestrial attractions visited en route included the Flowering Desert, which was indeed in full flower.

Over four full days more than fifty oral presentations were given, and there were nearly as many poster presentations. In spite of the large number of presentations there were no concurrent sessions forcing one to choose between hearing either one talk or another, and that was appreciated by many. This article can only mention a few of the papers, but abstracts of all will be published in the next issue of Penguin Conservation. When the conference ended there were no plans for the publication of a conference proceedings volume, although some papers will appear in the journal of the Chilean Ornithological Society. After that, this journal will be working with authors regarding publication of some of the remaining papers here.

Emperor penguins' yearly cycle

The opening presentation of the conference was made by Gerald Kooyman, and was a summing-up of what has been learned about the annual cycle of the emperor penguin since 1902 when Robert F. Scott's British National Antarctic Expedition located the first known emperor colony as well as a moult site. Early work depended on dogsleds for transport (men put on the harnesses when the dogs died) and the dangers and suffering were so extreme it is hard to believe that human beings could survive. [See A. Cherry-Garrard's extraordinary book, The Worst Journey in the World, his first-hand account of a trip to find brooding male Emperors and return with an egg, from what was then believed to be the "most primitive" of all bird species.]

Working conditions have changed dramatically for polar researchers, and so have the methods and instruments used to follow, observe, and record the behavior of penguins and other animals. Kooyman noted how the invention of the submersible computer in the 1980s made possible the study of foraging behavior through recording devices attached to the penguins to record where the penguins went and to some extent what they did. In the 90's, devices using satellite telemetry were developed, increasing even more the information that could be gathered. Kooyman himself, and colleagues, built the first time-depth-recorder around 1975 and found emperor penguins diving to 274 m (900 ft). Later work has extended that depth to 518 m (1700 ft), though such deep dives seem to be uncommon.

Emperors breed around the edge of the Antarctic continent, on ice well in from the water, and preferably in locations sheltered somewhat from the wind. But their seasonal movements after breeding have long been the subject of conjecture: few juveniles are seen in the Antarctic after they fledge, and the breeding adults also leave each year about Christmas-time. Until recently their destinations were unknown, but the work on which Kooyman reported has closed many gaps in the knowledge of this species' annual movements.

In one of his recent studies, the adults tagged with telemetry devices left the breeding area at Cape Washington and travelled 1200 k (746 miles) across the Ross Sea to a moulting location near Marie Byrd Land. While the birds moult they must stay out of the water, so they need stable areas of ice that will remain without breaking up for at least 30 days. After moult the birds are very lean and weak, and must quickly find a rich feeding area where they can regain their strength. It is during moult, he believes, that the emperors experience their highest mortality. About three months after moulting the adults will head back to their breeding colony. Kooyman has found that the young emperors from Cape Washington leave the Antarctic and go to the polar front, where they may feed on the same prey as the king penguin does.

Kooyman noted several potential threats to the emperors, given what is now known about their life cycle. Industrial fishing operations are spreading into the Southern Ocean and even into the Ross Sea. There is some direct competition between penguins and humans for the same prey, but another danger lies in the unrestrained nature of this fishery. At least one of the commercial species, the southern toothfish, is long-lived and slow to reproduce and hence could be fished out quickly. In that case the killer whales might switch prey from the large toothfish to penguins; a similar event occurred in the Aleutians where the killer whales switched to eating sea otters instead of sea lions. If that happens, we will need to know as much as possible about population trends among the emperors in order to detect and measure a decline in their numbers.

Also, emperors rely on the sea ice being intact for about nine months; as it is, the ice begins to break up only a week or two after the chicks fledge and take to the sea, not much of a margin of safety. A continuation of the present warming trend could be disastrous for this extraordinary diving bird.

This presentation contained three themes that appeared frequently in other papers:

- One thread had to do with changes brought to research by the smaller more powerful telemetry devices which have been developed recently. Researchers are now able to collect more data less intrusively (although sometimes very
expensively), and the fruits of this were evident in the work of others at the conference. Some were using tiny temperature sensors to measure internal temperatures of penguins' throats and stomachs while they forage at sea, since sudden drops in temperature, plotted against time and location, show exactly when and where the bird actually fed.

- Foraging, a major topic of this study, was by my count the subject of 15 papers, more than on any other topic. The new instrumentation has expanded the amount of work in this area, because so much more can be done, so many more questions asked and answered.

- Finally there was, naturally, widespread concern with the future survival of penguins under the onslaught of threats which are mostly related to human activities: climate change, overfishing, pollution of the ocean, even direct human contact. There were five papers which measured in various ways the immediate effects of human presence upon different penguin species.

**Humboldt penguin count**

Braulio Araya spoke about the findings of the 1999 census of Humboldt penguins in Chile. At the Humboldt penguin Population and Habitat Viability Analysis in 1998, Peruvian and Chilean researchers agreed to carry out censuses which would use similar methods and take place at the same point in the birds' annual cycle so that the results would be comparable.

This was the first Chilean census since then. It counted many more penguins than in previous years; the population hadn't changed, but more individuals were present to be counted because the census was carried out during the moult when all the penguins are on land for a prolonged period. The 2000 census found 30,000 Humboldt penguins in Chile, while in 1998 the figure was 7500.

The great importance of population numbers is in how they change over time, providing evidence of increase or decline, and the rate of change.

The coordinated Peruvian/Chilean censuses will give us data in the future that is much more meaningful than that of past counts, but right now this year's figures stand alone—they aren't comparable to the figures from previous years since they were done using different methods.

**The tell-tale egg**

Peter Barham, a polymer physicist at the University of Bristol's Wills Physics Laboratory, presented a paper entitled "Incubation of African penguin eggs, finding out how the birds do it."

Thanks to the enthusiasm he and his wife Barbara have for penguins, they attended the 1996 conference also. After learning of researchers' interest in improved egg design Barham has put his expertise, and his graduate students, to work on the problem.

His 1999 article in *Penguin Conservation* (12(2):4-10) described progress in using new materials and a radically different design for bands, and at this conference he had a new set of prototypes in his pocket. The material is flexible and will expand slightly to accommodate the swelling of penguins' flippers during moult. The flexible material also reduces drag in the water, at least in lab tests. There has been considerable concern about some of the present bands used on wild penguins, since they are not flexible and could (some say they do) increase the energy required to swim.

The latest prototypes from Barham's lab will be tested by zoo penguins to see how they stand up, and whether they cause feather wear or any other problems for the penguins. Further improvements may be needed before the bands are tested on wild penguins.

Barham has also been helping to design an "instrumented egg" to be put under an incubating penguin and measure temperature and egg movement (rotation), in order to improve artificial incubation success. The idea is not a new one, but there is always room for improvement in the device used.

So far he and his colleagues have used the various egg-models with only two nesting pairs of African penguins at the Bristol Zoo. The instrumented eggs measured tilt (to record how the parent moves the egg) and temperature.

In brief, the data showed that: Rotation was around the long axis; the egg sat with blunt end up; parents didn't change the axis (orientation) of the egg, but moved it around the long axis; there was no correlation between time of day and egg temperature; moving lasted less than 30 seconds; all 4 birds behaved similarly. Moves were mostly between 45-90°, and most were moved anti-clockwise; eggs were moved more often during daylight hours, with much longer intervals at night; there was no significant difference around feeding times. Often there was little or no visible movement of the adult when the egg was being moved.

Temperature of the egg ranged between 35-37 °C (between 95 and 98.6 °F). Data (from one pair only) showed a change in temperature during the course of incubation, starting at 34 °C and going up to 37 °C after about 4 days. This is reported very tentatively, however, since it may have been caused by the size of the instrumented egg being used at that time. The warmest part of the egg is not always the top, and is 1.5 - 2 °C warmer.

Nest relief was not recorded, so the data cannot be correlated with the time when the parents changed places.

The group continues to collect data from several bird species, working toward the distant goal of making an incubator in which temperature and rotation would be programmable by species. So far the data collected has been used only in flamingos, where artificial incubation was adjusted and hatching success was higher than usual: three eggs were incubated, and all three hatched.

**Adélie penguin breeding success**

Judy Clarke and Knowles Kerry have been studying an Adélie penguin breeding colony in East Antarctica since 1990, and reported some of their findings.

This report focused on the relation between breeding success and the beha-
C. Cheney: A short report from the Fourth International Penguin Conference

The study collected data on 400 tagged adults for 8 breeding seasons. All the birds in the study were of known sex, and known to be feeding chicks. Birds were individually identified with transponders. They were automatically weighed as they went to and returned from their nests, to measure the size of the meals being fed to the chicks and record how long the parents were away foraging. The automatic weighing system was developed by the researchers for this project, and refined over the seasons. Stomach flushing was also used on occasion to find out what the composition of the food was.

They found that the factors most strongly connected with breeding success were the presence of large amounts of mature krill in the diet being fed to the chicks; the size of meals; and the duration of the parents’ foraging trips.

In years when food supplies are abundant, an Adélie pair may fledge two chicks, lighter in weight, rather than one heavy one. In years when the sea ice was more extensive, fledging rates were lower. In such years, the parents had to travel farther to and from the ocean, and keep undigested the food they were bringing to the chicks. It was also observed that during the early stages of a foraging trip when the penguins were eating “for themselves” rather than to bring food back to the chicks, stomach motility and pH were higher than in the latter part when digestive enzymes were deactivated, preserving the food for the young.

While snapping up krill underwater, the penguins can apparently distinguish female from male krill, and the vast majority of their diet is made up of mature or gravid females.

Our thanks to the organizers and sponsors

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On behalf of all the conference attendees, Penguin Conservation wishes to thank the organizers and sponsors for making this Fourth International Penguin Conference possible, and successful.

Guillermo Jorquera-Luna, Chair of the Scientific Committee, was the primary organizer, assisted by Rory Wilson. The complicated logistics of making arrangements for a hundred attendees went well, starting (from the attendee’s point of view) with meeting people at the airport. This was accomplished by the Organizing Committee: Carmen Gloria Ojeda (Chair), Felipe Sepúlveda, Maritza Cortés, Macarena Contreras, Julieta Muñoz, Pablo Zamorano, and Cristian Cortés.

On the two days following the conference there was a meeting to formulate conservation action plans for the Spheniscus penguins—the penguins currently most threatened are in this genus. This workshop was a condensed version of a Population Habitat and Viability Analysis workshop (PHVA) like the one held in 1998 for the Humboldt penguin. It was largely organized by Susie Ellis, from the Conservation Breeding and Specialist Group of IUCN. Speakers at the conference had presented some important new information about these species, which helped the workshop members to assess the threats and formulate positive actions. Meeting space and computers were provided by the Universidad Católica del Norte, in Coquimbo. The Universidad was also an important sponsor of the conference.
Diseases and parasites of penguins

Abstract
The study of diseases in wild penguins is important for the identification of endemic diseases and the detection of exotic diseases should these occur. It is also important in the understanding of the degree to which disease may be expected to influence the results of biological studies. Results may be confounded and interpretation made difficult by the transient and long-term presence of disease particularly if it is at the sub-clinical level. We present here a compilation of diseases and parasites recorded for all species of penguins present both in the wild and in captivity. Normal values for blood biochemistry and haematology are given as an aid to the identification of illness in penguins.

Introduction
There appear to be few studies and no statistics on the incidence of disease among penguin populations in the wild despite extensive biological studies of all species. The reports by Harrigan (1988) and Cunningham et al. (1993) on Little penguins (Eudyptula minor) are the most comprehensive investigations of disease for any penguin species in the wild. Disease in wild birds is generally diagnosed post mortem. There are, however, reports of individual diseases, parasites and pathogens scattered throughout the literature which enable a broad picture of the pathology of penguins in the wild to be assembled.

Much of the pathology of penguins has been reported from birds maintained in captivity, for which there is an extensive literature, for example Stoskopf [sic] and Beal (1980), Davis (1967), Fiennes (1967), Todd (1978) and Gailey-Phipps (1978a,b). Many of the disorders associated with captivity are due to locally occurring pathogens that may not be experienced by birds in the wild.

This paper attempts to bring together knowledge on the diseases and parasites of penguins both in the wild and in captivity for use in conservation and management. Penguins in zoos provide very popular displays, but these are provided at considerable cost (Olney 1978). Keeping captive birds healthy is obviously very important and in the long term may have implications for survival of some species that could become extinct in the wild. The study of diseases in wild penguins enables the identification of endemic disease and the detection of exotic pathogens, and provides information on which to fashion regulations to protect both penguins and other avian species. It is important in the monitoring of possible impacts of human activity especially fishing (see below). The results of monitoring may be confounded by the occurrence of disease particularly at the subclinical level.

We present also a summary of constituents of blood of normal birds in the wild that may be of use in identification and diagnosis of disorders. Information is drawn from the literature and supplemented with data from our study of Adélie penguins (Pygoscelis adeliae) near Mawson, Antarctica.

Parasites and diseases
The following compilation provides a broadly based summary and discussion of parasites and diseases reported from all species of penguin and for which information is available readily in the literature. The list is comprehensive rather than exhaustive. Symptoms, diagnosis and treatment are not discussed and the reader is referred to the literature. Additional information from the early literature may be obtained from the bibliography compiled by Williams et al. (1985). There are many areas of taxonomic difficulty, particularly in relation to the identity of invertebrate parasites listed in the various research and taxonomic papers. Data are derived from a wide variety of sources and for this reason taxonomic inferences should not be drawn. So far as possible synonyms have been avoided and the most recent nomenclature used to identify invertebrate species and other micro-organisms. Where a major revision of the group of organisms has occurred, reference is made to both the original paper and the revision.

A distinction is made between birds found in the wild exhibiting disease and those held in captivity. Further, birds which were captured in the wild (wild-caught) but exhibited symptoms of disease or the presence of infectious agents soon after being taken into captivity are identified. The source of infection in these cases is not known.

Ectoparasites
Fleas and ticks are both common ectoparasites on penguins in the wild (Table 1). Ticks can also act as carriers of viral diseases and blood parasites.

The tick Ixodes uriae has a wide distribution, being found on most subantarctic islands and the Antarctic Peninsula (Murray 1967). It is found also associated with other species of seabird in the northern hemisphere. At Macquarie Island, I. uriae are found most commonly on royal (Eudyptes chrysolophus schlegeli) and rockhopper (Eudyptes crestatus) penguins. Chicks are most frequently infested. The ticks are found around the
eyes, at the commissures of the mouth, on the webs between the toes and around the cloaca. Gentoo penguins (*Pygoscelis papua*) are less commonly infested due to the non-permanent nature of their nests. Royal penguins nest densely thus providing the best food source for ticks. Heavy infestations may kill, or contribute substantially to the death of, penguin chicks and some adults. Ticks require the nests of their hosts to be sheltered and well-drained.

Ticks of the genus *Ornithodoros* are found on penguins from tropical and temperate regions, including Humboldt (*Spheniscus humboldti*), Galapagos (*Spheniscus mendiculus*), African (*Spheniscus demersus*) and Little penguins (*Eudyptula minor*). It has been suggested (Hoogstraal et al., 1985) that irritation produced by the feeding of numerous *O. (Alectorobius) spheniscus* upon Humboldt penguins may cause the birds to abandon their eggs.

*Paraplysus* species of fleas are found on many penguins. The flea *P. magellanicus heardi* breeds on Macquarie Island in sheltered nests of the rockhopper penguin; only the adult flea visits the bird to breed. These fleas are seen easily on the brood patches of affected penguins (Murray and Vestgens 1967).

Fleas have not been found on Antarctic penguin species since they spend parts of their life cycles off the host and thus need suitable nest environments with shelter from the weather.

Biting lice have been found on all subantarctic and Antarctic penguins except the gentoo and chinstrap (*Pygoscelis antarctica*), and live permanently on the birds. Penguin lice are similar to other bird lice, living and breeding on the bird. They do not suck blood but rather eat feathers or skin debris (Murray 1964).

**Endoparasites**

Nematodes, cestodes, trematodes and acanthocephala have been reported in many species of penguin (Table 2). It should be noted that the taxonomy of some species is under revision and the identification of others is problematical since they have been identified from juvenile stages only. Some species may also be accidental occurrences due to being ingested in the food. The developmental cycle for any species of cestode in penguins has not been determined or the intermediate hosts identified (Zdzitowiecki 1993).

Endoparasite burdens tend to be heaviest in juvenile birds, and in all penguins—for example Little penguins (Norman et al. 1992)—contribute to mortality when combined with starvation and other forms of stress.

Nematodes are the most commonly found gastrointestinal parasites, and several species have been documented. *Stegophorus paradeliae* has been found in Adelie, rockhopper, gentoo and macaroni penguins (*Eudyptes chrysolophus*). *Contracaecum heardi* parasitises rockhopper, gentoo, king (*Aptenodytes patagonicus*) and macaroni penguins, and *Stomachus* species are found in gentoos (Mawson 1953). *Tetrames wetzelii* was first isolated from the proventriculus of Rockhopper penguins at the Kerguelen Islands (Schmidt 1965).

The trematode *Mawsonotrema eudytulae* is known to contribute to mortalities in Little penguins through damage to the liver. *Cardiocephaloides physalis* was reported to cause death in the chicks of African penguins through infestation of the small intestine (Randall and Bray 1983). Renal flukes of unknown species have been found in healthy Little penguins and appear not to cause serious disease (Crockett and Kearns 1975).

**Protozoans and blood parasites**

A variety of protozoan species have been recorded infecting penguins (Table 3) but of these only a few produce symptoms of disease at the clinical level. Most do not appear to be serious pathogens but may render birds more susceptible to secondary infections or sensitive to stress factors such as weather or poor nutrition. All are spread by arthropod vectors, particularly ticks, and—in the case of malaria—by mosquitoes.

No blood parasites have been found in smears from penguins in Antarctic or subantarctic regions. Species investigated include Adélies, emperors (*Aptenodytes forsteri*), chinstraps, gentoos, kings, royals, rockhoppers and macaronis (Jones 1988, Jones and Shellam 1999). These negative findings are attributed to lack of suitable vectors in cold climates since blood parasites are known to occur in penguins from more temperate regions.

Jones and Woehler (1989) demonstrated the presence in low numbers of the trypanosome *T. eudyptula* in the blood of Little penguins. The actual vector of these parasites is unknown but potential organisms include mites, mosquitoes, flies and ticks. Avian trypanosomes rarely cause harm to their hosts, and no evidence of ill effects has been observed in infected penguins.

Malaria due to *Plasmodium relictum* has been reported in a wide variety of captive penguins, and *P. elongatum* has been observed in wild and captive African and Humboldt penguins. Both *Plasmodium* species have been found together in some captive African penguins (Beier and Stoskopf 1980). *P. cathemerium* has also been recorded in a king penguin (Luera-Carbo 1965, cited by Bennett et al. 1993). Avian malaria is transmitted by mosquitoes and is an important cause of mortality in penguins in zoos in North America and Europe where it is maintained in the wild bird-mosquito cycle (Cranfield et al. 1990, 1991). Plasmodium species appear to be absent from birds in the Australasian region (Bennett et al. 1993). Penguins become infected when interjected into an area of endemic transmission (Beier and Stoskopf 1980). Malaria has been successfully treated with primaquine and chloroquine in zoo environments. Birds which survive rarely develop symptoms thereafter; however, some individuals carry the parasite for many years after initial infection and treatment (Cranfield et al. 1990, 1991, 1994). An enzyme-linked-immunosorbent assay (ELISA) has been developed for the detection of anti-*plasmodium* spp. antibodies in African penguins and evidence of maternal antibody transfer detected (Graczyk et al. 1993, 1994b&c).
The avian blood parasite *Leucocytozoon tawaki* has been found in wild Fiordland crested penguins (*Eudyptes pachyrhynchos*) in New Zealand (Fallis et al. 1976). The vector is a simulid fly *Austrosimulium unguiculatum*. A Little penguin also became infected when exposed to simulid flies alongside an infected Fiordland penguin. *L. tawaki* does not appear to be a serious pathogen of these penguins. A leucocytozoon also believed to be *L. tawaki* has been recorded in blood smears from African penguins (Earle et al. 1992).

Lethal toxoplasmosis (*Toxoplasma gondii*) has been reported in a Little penguin held for rehabilitation in Australia (Mason et al. 1991). Toxoplasmosis is a common parasitic disease of domestic sheep in Australia and it is likely that infection occurred through the sheep meat that was fed to the penguin for several weeks (Mason pers. comm.). Toxoplasmosis was also reported in penguins by Ratcliffe and Worth (1951). However Fleischman et al. (1968) suggest that these birds may in fact have had malaria since the organisms are difficult to separate at certain stages in their life cycles.

Babesiosis, *Babesia pieticei*, is endemic in African penguins but does not cause clinical signs or morbidity. It may, however, contribute to illness in combination with other agents such as malaria or leucocytozoanososis (Brossy 1993). A piroplasmid, possibly *Babesia*, has also been found in Little penguins in Australia. It is tick-borne and causes mild regenerative anaemia in juveniles (Cunningham et al. 1993, Cunningham pers. comm.).

**Viral diseases (Table 3)**

Avian paramyxoviruses (APMV) are widespread among Adélie penguins in Antarctica and also subantarctic royal penguins (Morgan and Westbury 1988; Morgan et al. 1978). Antibodies to Newcastle disease virus (NDV) have been demonstrated in serum from Adélie, royal, and Little penguins (Morgan and Westbury 1981; Morgan et al. 1978). The significance of these antibodies is uncertain; however, it is known that penguins are susceptible to pathogenic virus strains since disease has occurred in Adélie penguins believed to have become infected in the wild (Pieron and Prow 1975) and in a captive king penguin (Krauss et al. 1963).

Non-pathogenic paramyxovirus strains have been isolated from the cloacas of royal and king penguins and antibodies detected in serum from Adélie and Little penguins (Morgan and Westbury 1981). The pathogenicity of these viral isolates was low in chickens, and although the effects on penguins are unknown, they are likely to be asymptomatic. Paramyxoviruses may cause disease if in combination with other agents and may also help produce immunity to NDV. Antibodies to NDV and APMV-1M have been shown to be only transiently present in Little penguins after infection (Morgan and Westbury 1988). There may be some factor that prevents spread of virus infection until after chick hatching since more antibodies are detected late in the breeding season than earlier.

Serum antibodies to avian influenza virus H7 were detected in six of 285 sera from Adélie penguins at Casey (Morgan and Westbury 1981). Many 4-5 wk old Adélie chicks died from an unknown cause on Petersen Is. (Casey) in the same year, but no clinical disease was observed and post mortems were not carried out. Antibodies to avian influenza A viruses have been detected in Adélie penguins in the Ross Sea Dependency (Austin and Webster 1993). Avian influenza viruses are common in flying birds; thus it is not surprising to find antibodies in other avian species such as penguins. However, the significance is uncertain since some forms cause disease while others do not.

Antibodies to infectious bursal disease virus (IBDV) have been detected in shearwaters and penguins, although clinical disease has not so far been documented in these species. Recent studies have demonstrated the presence of antibodies to IBDV in emperor and Adélie penguins at near Mawson in eastern Antarctica (Gardner et al. 1997). It is not known how these birds became exposed to the virus, or whether any degree of disease or immunosuppression has occurred as a result.

A recent survey of sub-Antarctic rockhopper penguins has provided the first evidence of exposure to other avian viruses in penguins (Karesh et al. 1999). Antibodies to avian adenovirus, avian encephalomyelitis virus, infectious bronchitis virus (a coronavirus) and avian reovirus were found. No symptoms of disease were apparent, although the blood biochemistry of birds with antibodies to infectious bronchitis virus indicated that some degree of physiologic response had occurred.

Antibodies to flaviviruses have been demonstrated in Little penguins and a pathogenic flavivirus strain was isolated from ticks on Macquarie Island (Morgan et al., 1985). Antibodies have also been detected in occasional serum samples from royal, king and rockhopper penguins (Morgan et al. 1981). The low prevalence suggested that either infection rates are low or that disease is rapidly fatal and few birds survive. Arboviruses have been isolated from ticks (particularly *Ixodes* spp.) associated with seabird colonies (e.g. Doherty et al. 1975). The occurrence of related viruses in widely distributed seabird colonies indicates that seabirds transport viruses over large distances (Nuttall 1984). Although overt disease in seabirds has rarely been demonstrated, the effect of arboviruses on seabird populations is difficult to assess.

A disease resembling the virus disease puffinosis in Manx shearwaters (*Puffinus puffinus*) was reported in Gentoo penguins at Signy Island, Antarctica by MacDonald and Conroy (1971). Several hundred chicks were found dead. Although they appeared in good bodily condition all had multiple ulcers, 2-4 mm in diameter, on the dorsal surfaces of both feet. The infectious agent was not proven, however, and Adélie and chinstrap penguins in adjacent colonies were unaffected.

Please turn to page 8
A herpes-like virus infection in an African penguin was reported by Kincaid et al. (1988). The infection was characterised by debilitation and respiratory distress.

**Bacteria, spirochetes and fungal diseases (Table 3)**

Surveys of the intestinal flora of various penguins in the wild have identified the presence of various apparently non-pathogenic bacterial species in healthy birds. These include *Escherichia coli*, *Alcaligenes faecalis*, *Citrobacter freundii*, *Enterobacter sp.*, *Paracolon sp.*, *Bacillus spp* and *Pseudomonas* strains (Soucek and Mushin 1970). Some gut samples were sterile for aerobic gram-negatives, but all contained microorganisms (e.g. *Staphylococcus epidermis* and *Streptococcus faecalis*), and all species harboured *E. coli*. Diet affected the numbers of anaerobes found; birds eating mainly crustaceans were most likely to give negative results, probably due to the antibiotic properties of the algae present in water and soils.*

Enteritis due to *Plesiomonas shigelloides* was isolated from one gentoo penguin at South Georgia and believed to be recently introduced (Olsen et al. 1996). *S. typhimurium* and *S. anatis* have been known to cause disease in captive penguin species (Stoskopf and Beall 1980). *Salmonella typhimurium* has been isolated from captive African penguins (Cockburn 1947). Surviving penguins can become carriers of this disease and transfer infection to other birds. Chronic enteritis due to *Edwardsiella tarda* infection has been reported in captive rockhopper penguins (Cook and Tappe 1985). *Campylobacter* species have been isolated from faecal samples in gentoo and macaroni penguins at South Georgia (Broman et al. 1998).

Antibodies to the *Chlamydia* group of bacteria have been isolated from Adélie and emperor penguins in Antarctica and from rockhopper, royal and gentoo penguins at Macquarie Island (Moore and Cameron 1969; Cameron 1968). The wide distribution of positive specimens indicates the probable circumpolar distribution of the *Chlamydia* group that may have been brought south by flying birds. The significance of the above findings is unknown, but it is possible that psittacosis (*C. psittaci*) may contribute to chick mortality in penguin colonies (Cameron 1968).

Pure cultures of *Pasteurella multocida* (avian cholera) have been isolated from dead rockhopper penguins on Campbell Island where the disease has been observed on more than one occasion (de Lisle et al. 1990).

Two cases of localised tuberculosis (acid-fast bacilli, possibly *Mycobacterium*) in the metatarsal-phalangeal joints of two captive penguins were reported by Hamerton (1936, 1937). The organisms may have entered through severe bumblefoot lesions (Stoskopf and Beall 1980). Lensink and Dekker (1978) reported tuberculosis as the cause of death of an African penguin but no additional details were given.

Death from *Erysipelothrix septicaeemia* of a captive African penguin was reported by Lensink and Dekker (1978). The infection may have been the result of contaminated fish (Stoskopf and Beall 1980).

Antibodies to *Borrelia burgdorferi*, the tick-transmitted spirochete that causes the zoonosis Lyme disease, have recently been detected in king penguins in the Crozet Archipelago (Gauthier-Clerc et al. 1999). The effect of this agent on the penguins is unknown, but the organism is likely to be widespread among tick-infested birds.

Aspergillosis (due to *Aspergillus fumigatus* and rarely to *A. flavus*) is a common fungal disease in captive penguins where it is usually secondary to stress or other diseases (Stoskopf and Beall 1980). It is, however, one of the most common causes of death in penguins and is usually manifest shortly after capture or arrival at the zoo (e.g. Khan et al. 1977). There are two forms: respiratory (most common) and central nervous system aspergillosis. Healthy penguins are normally able to resist the disease and the most effective treatment of sick birds used to be with endotraceal amphotericin B (Fix et al. 1988). Itraconazole has been used successfully in more recent years and an ELISA test developed for diagnosis (Hines et al. 1990, Reidarson and McBain 1992). Preventative vaccination is possible (Yearout 1988).

Although aspergillosis is rarely seen in wild penguins, the pulmonary form has been diagnosed in dead beach-washed Little penguins (Obendorf and McColl 1980). Beach-washed Little penguins (usually juveniles) are frequently found along the southern coastlines of Australia. The most common cause of mortality in such birds is starvation exacerbated by heavy parasite burdens, but other lesions including coccidiosis and aspergillosis are occasionally seen (Obendorf and McColl 1980). *A. fumigatus* has been isolated from ornithogenic soil in the vicinity of human habitations in Antarctica (Wicklow 1968). Soils from more isolated regions were not contaminated, which implies that the fungi were likely to have been introduced to Antarctica through human activities.
Other diseases and trauma

Several diseases of unknown aetiology have been recorded, including a nephritis of young chicks of African and Humboldt penguins which is rapidly fatal (Stoskopf and Beall 1980). African penguins have also succumbed to hepatitis and salpingitis (Lensingk and Dekker 1978). Renal stones successfully treated by extracorporeal shockwave lithotripsy were reported in a captive Magellanic penguin by Machado et al. (1987). Ruptured uropygial glands have been observed in captive gentoo penguins, and can be treated surgically (MacCoy and Campbell 1991).

Various carcinomas have been observed including a cholangiocarcinoma in a Humboldt penguin (Shigemi 1979) and a lymphocytic sarcoma/mixed cell lymphoma in Little penguins (Reece 1992). Malignant melanomas are rarely found in birds; however, one such tumour was diagnosed in a captive macaroni penguin (Kufuor-Mensah and Watson 1992). Cataracts have been found in a Little penguin (Reece et al. 1992). In some seasons we have observed otherwise healthy Adélie penguins in breeding colonies with serous discharge from one or both eyes.

We have archival film that shows a colony of Adélie penguins near Mawson in 1973 where there were large numbers (possibly hundreds) of well-grown chicks dead and others ataxic. No samples were taken and the cause remains unknown (Kerry et al. 1996). Substantial mortality among yellow-eyed penguins (Megadyptes antipodes) in New Zealand was observed during one summer and, despite extensive culture of tissue specimens, no causal organism was detected. A diatom toxin was suspected but not positively identified (Gill and Darby 1993).

Various traumas are observed in penguins, both due to natural causes (especially predator attack) and human-induced. Injuries range from superficial abrasions to deeply penetrating wounds and limb fractures. These derive from normal accidents as well as close encounters with predators such as leopard seals (e.g. McFarlane 1996). We have occasionally observed other traumas such as cloacal prolapse and paralysis in Adélie penguins. Human-induced injuries include those caused by propellers, dogs, flipper band abrasion (Clarke and Kerry 1998) and stomach flushing. Chronic petroleum pollution has been identified as a significant mortality factor for Magellanic penguins along the Argentinean coastline and may be depressing population numbers of that species (Gandini et al. 1994).

Congenital disorders including malformed beaks and the absence of flippers have been observed in the Little penguin by Reilly and Balmford (1975).

Nutritional disorders have been documented in captive penguins but little is known about the occurrence or importance of such disorders (other than general starvation) in wild populations. Nutritional problems that have been reported for penguins in zoos include thiamine deficiency (Harrigan 1988), nutritional secondary hyperparathyroidism due to vitamin D3 deficiency and iodine-induced hyperplastic goitre (Russell 1977).

A major problem in captive birds is bumblefoot caused by bacterial infection of the soles of the feet damaged by wet and possibly unsuitable surfaces in the zoo environment (Gailly-Phipps 1978a, 1978b; Stoskopf and Beall 1980). Healing has been induced, however, by providing a dry soft surface (kitty litter or carpet) or dry decking (Todd 1978) in the enclosure.

Clinical pathology

The cellular, chemical and biochemical constituents of penguin blood are detailed in Tables 4 (erythrocytes) and 5 (leukocytes). Table 4 includes the erythrocyte count (number concentration of erythrocytes), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin expressed as the mass concentration of haemoglobin in erythrocytes (MCMC), and mean corpuscular volume (MCV) i.e. the volume of one erythrocyte. Haematocrit is given as the packed cell volume (PCV) of erythrocytes in relation to whole blood, and haemoglobin concentration (Hb) as the concentration in whole blood.

The total erythrocyte count in most bird species is higher in males than females, increases in autumn, increases with age, increases with altitude and latitude and decreases after bacterial infections such as Salmonella gallinarum and E. coli (Stoskopf et al. 1983).

Haematocrit increases in summer, is greater in males than females, increases with age, increases in dehydration, drops slightly in moult, decreases in egg laying and decreases in anaemia and parasitism (Stoskopf et al. 1983). Haemoglobin levels increase with age, are higher in males than females, increase at altitude, and are greater in winter (Stoskopf et al. 1983).

Penguins have higher Hb and PCV values and larger erythrocytes than most other avian species. By the end of moult rockhopper penguins have lower Hb, RBC, PCV and MCH, and higher MCV than before (Hawkey et al. 1989).

Leukocytes

Heterophils are the most numerous white cells in normal penguin blood, in contrast to many other bird species where the lymphocyte is most common. Eosinophils are the second most common leucocyte in penguins (Zinsmeister and VanDerHeyden 1987a).

Heterophils in birds in general are elevated in stress, bacterial infections and inflammatory reactions; eosino
Blood Biochemistry
(Tables 6 and 7)
Total blood protein levels in birds are
low in malnutrition and acute infections.
Values lower than 20g/l indicate poor
prognosis. Serum protein increases in
egg laying, dehydration and chronic
infections. Alkaline phosphatase
increases in growth, rickets, primary
hypoparathyroidism, fracture repair,
osteoarthrosis and aspergillosis. Choles-
terol levels increase with age and tend to
be higher in females. Uric acid increases
in ovulation, starvation, trauma and
goat. Calcium levels increase 2 weeks
prior to laying and decrease in fasting,
hyperthermia, and renal failure. Phosp-
hate levels increase 2 weeks prior to
laying and decrease during hyperthermia
and fasting. Potassium levels increase
in hyperthermia while sodium and
magnesium levels decrease (Stoskopf et
al. 1983). Serum concentrations of
gamma-glutamyltransferase (GGTP),
alanine aminotransferase (ALT), alkaline
phosphatase, creatinine, uric acid and
triglyceride increase in avian malaria
(Graczyk et al. 1995).
Diurnal variations in blood glucose,
urea, triglyceride and cholesterol levels
found in penguins are similar to those
found in other bird species (Ferrer et al.
1994). Glucose levels vary widely with
season, decrease in fasting, tend to be
higher in females than males and increase
in hyperthermia and excitement. Heat
stress in penguins leads to increased body
temperature. If body temperature exceeds
40°C then blood pH increases (alkalosis) and arterial pCO2
decreases (hypocapnia). Ventilation rate
also increases significantly (Douglas et al.
1976).

Discussion
This review shows that penguins in
the wild are susceptible to an array of
infectious and parasitic diseases but that
clinical signs of disease are rarely obvious
and usually not reported. However our
knowledge as shown from this review is
meagre and fragmentary even for species
subject to extensive scientific studies.
Incidence of disease—even using
immunological methods of survey—
is difficult to assess. The presence of
antibodies suggests that exposure to
pathogenic viruses may have occurred
although this may indicate only the
presence of serologically related non-
pathogenic viruses. The possibility exists
that these non-pathogenic species may
provide cross-immunity to the patho-
genic strains. The presence of particular
pathogens also does not necessarily
indicate the presence of clinical disease,
although symptoms may occur under
the influence of other contributing
disorders including stress.

Studies in zoos show that penguins are
susceptible to a wider variety of diseases
than those that have been detected or
reported in birds in the wild. Penguins
spend most of their life at sea and many
species breed on the Antarctic continent
and on islands isolated from other areas
of human habitation. They are thus to a
marked degree isolated from other avian
species and vectors of disease. The
absence of appropriate vectors and the
inability of infectious agents to survive
under maritime or polar conditions may
have limited the occurrence of disease.
The observed incidence of disease in wild
populations can be expected to be low
since many species are observed only
during their breeding seasons, and sick
birds are likely to die at sea away from
their breeding colonies.

The diagnosis of disease in penguins in
the wild is hampered by the lack of
information on both the diseases and on
what is normal and what is pathological.
There have been very few clinical investi-
gations on healthy birds although some
biochemical and haematological data
such as that contained in Tables 4-7 are
available. Few matching pathological
data are available, however.

The treatment of illness in penguins in
zoos has economic, ethical and aesthetic
importance. It is also important should
species become endangered and ulti-
mately confined to zoos. The large
percentages of birds that die during
transport or in captivity, particularly
during their first weeks, attest to the
difficult problems to be solved. Fortu-
nately, progress has been made on the understanding and treatment of aspergillosis and malaria, which are the major causes of death of captive penguins (Stoskopf and Beall 1980, Graczyk et al. 1994a-d, 1995).

Treatment of injuries and illness in wild birds is difficult and rehabilitation often unsuccessful (Harrigan 1988). Ethical problems arise on euthanasia. We have adopted a policy of leaving such birds alone unless the trauma is caused by a human agent, in which case we may treat or kill the bird.

The study of diseases in wild penguins is important for the identification of endemic diseases and for the detection of exotic diseases should these occur. It is also important in the understanding of the degree to which disease may be expected to influence the results of biological studies. Results may be confounded by the presence of disease in the wild penguin population, which may mask early subtle changes caused by environmental factors.

The detection and estimation of disease is of particular importance to long-term studies such as those taking place under the Convention for the Conservation of Marine Living Resources (CCAMLR) Ecosystem Monitoring Program (CEMP) (CCAMLR 1991). This program, as a first step, seeks to determine the natural variation in selected variables (relating to feeding ecology and reproductive success) in order to evaluate possible effects of the harvest of krill on its predators. Predator species include Adélie, chinstrap, gentoo and macaroni penguins. It is likely that changes in predator performance outside the norm will be difficult to detect and that disease may mask early subtle changes caused by fishing activities.

Knowledge of infectious diseases is also necessary for quarantine and conservation purposes. The introduction of exotic diseases may have a devastating effect on penguin populations that live in isolated or remote colonies and have little natural immunity. Similarly, species of penguins may carry diseases which could infect wild or domestic birds, particularly poultry, if introduced.

Penguin populations at most breeding locations, particularly in the Antarctic and on subantarctic islands, have evolved in relative isolation. The Southern Ocean forms a barrier which very few avian species cross. This factor may well have protected the penguins from the major diseases found in birds and other species to the north. Distance prohibits contact with disease and inhibits the introduction of vectors or intermediate hosts.

The speed and volume of modern transport to Antarctica and the sub-Antarctic, and the number of people visiting the south polar regions as expeditionary personnel or as tourists, have increased enormously; this may increase the possibility of unwitting introduction of diseases. Good hygiene and good quarantine must be practised. The introduction of poultry products except for food, and their disposal into the Antarctic environment, are prohibited under the Agreed Measures for the Conservation of Antarctic Flora and Fauna, and the Madrid Protocol (Protocol on Environmental Protection to the Antarctic Treaty) provides additional protection.

Acknowledgements

We thank Richard Norman for providing key references and for his valuable comments on the manuscript, Margaret Deighton and Gordon Bennett for very helpful discussions on bacterial and plasmodium infections respectively, and John Cooper for help in tracking down obscure references. We are particularly grateful to KORDI for the opportunity to present this work at the Symposium.

References


Gardner, H., D. Boyle and A. Frost (in prep.) The bacterial flora from the cloaca of Antarctic penguins and skuas.


please turn to page 16
Natural engineering: the streamlining of penguins

A presentation on the hydrodynamics of penguins' swimming, by Rudi Bannasch, was accompanied by video of beautiful chains of vortices formed in the water currents by the motion of the penguins. Bannasch films the penguins as they swim, singly, in a specially built swim channel, a long narrow tank with clear sides. Cameras on rails can pace the penguin and film its motion from the side and from overhead, and a small dye dispenser on the penguin's back periodically lets out a bit of black dye that makes the currents visible. The above-water portion of the swimming channel—where the penguin comes up to breathe—is sealed, so that the exhalations of the penguin can be analyzed to help determine energy use.

Part of his work is in analysis of the fine points of penguin streamlining, using the penguins themselves and physical and computerized models. The deeper he looks, the more adaptations he finds. A body moving through water generates various kinds of turbulence; at the surface of the body it will function like drag, requiring more effort. With a model in a tank, adding a small object to introduce turbulence at the nose of the model actually reduces drag by creating a “more orderly micro-turbulence” than would be created otherwise. This same positive effect may be generated by the penguin’s beak.

According to Bannasch's calculations based on the shape of the Adélie, the highest underwater swimming efficiency is at a speed of 2.6 mps (5.8 miles per hour). Lower and higher speeds are less efficient, which matches the common behavior of penguins: swimming slowly, they swim on the surface, and when swimming faster than this optimum speed, they often “porpoise” or come up out of the water in a continuous curve that takes them back into the water again. Drag in air would of course be far less than in the water so this lets them make part of their progress at a lower energy cost. Porpoising is also a chance to breathe without slowing down.

This work provides more information about the energy use of penguins which is needed to know how much food they require (and thus estimate roughly the consumption required, in weight of fish, for a given number of penguins). It could also lead to more efficiently engineered human structures or vehicles; the penguin's streamlining is more applicable to that of inanimate objects than that of a fish, since the fish's body oscillates as part of its method of movement.

Death by entanglement

Patricia Majluf, principal investigator at the Punta San Juan Humboldt penguin reserve, reported on penguin mortality caused by entanglement in fishing nets. Gill nets catch fish by snagging their gills, and nets of a certain size mesh also snag penguins, causing them to drown.

Returning small-boat fishermen were asked about their catch, including whether any penguins had been caught. The type of fishing gear used, and location of fishing, were also recorded. She believes that the fishermen gave accurate information, since most of the observers were young fishermen themselves, known to the other fishermen, and no penalty is attached to the accidental deaths of penguins in the nets.

Seventy per cent of the 922 penguins caught during the study period were caught during one 20-month period. This mortality rate was unique in 20 years of research at Punta San Juan, and computer modelling at the PHVA showed that such a rate, added to other factors such as El Niño, could mean the end of the species. The usual number is believed to be less than a dozen per year. The rate depends on the type of net used, when it is deployed, and where; evidently at this period of high mortality the fishermen and the penguins were both fishing in the same small area. The fishermen were after cojinova (Seriolella violacea) and the penguins may have been hunting the small fish that the cojinova were feeding on.

Few detailed statistics are available about the Peruvian fishing industry's catch, but after reaching a fifty-year peak in 1986 or 1987, the catch of cojinova is now at its lowest point—close to zero—in that same time span.

Other fisheries in the region target the same fish the penguins eat, and overfishing thus threatens the penguins' food supply. Driftnets, the miles-long nets that sweep up every creature in the water, may entangle penguins, and may also reduce their food supply. The UN has issued a ban on driftnets; Majluf and others concerned about the Humboldt penguin hope to persuade the government of Peru to recognize and enforce this ban.

This has been just a sampling of the papers presented at the conference. Look for abstracts of all in the next issue, and some complete articles in a later issue.
Table 1. Ectoparasites of penguins. Most references are taken from Murray et al. (1991). This work should be consulted for the primary references.

<table>
<thead>
<tr>
<th>Ectoparasites</th>
<th>Penguin species affected</th>
<th>References</th>
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<tbody>
<tr>
<td>Ticks</td>
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<tr>
<td><em>Ixodes uriae</em></td>
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<tr>
<td><em>Ixodes kohlsi</em></td>
<td>Little</td>
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</tr>
<tr>
<td><em>Ixodes percavatus</em></td>
<td>Little</td>
<td>Reilly and Balmford (1975)</td>
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<td>Hoogstraal et al. (1985)</td>
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<td>Biting lice</td>
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<td><em>Nesiotinus demersus</em></td>
<td>King</td>
<td>Murray et al. (1991)</td>
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<tr>
<td>Mites</td>
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<td><em>Listronius robertsonianus</em></td>
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<td>de Meillon (1952)</td>
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<td><em>Parapsyllus longicornis</em></td>
<td>Little, rockhopper, gentoo, macaroni,</td>
<td>de Meillon (1952), Obendorf and McColl (1980)</td>
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<td></td>
<td>Magellanic</td>
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</tr>
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<td><em>Parapsyllus longicornis</em></td>
<td>Yellow-eyed</td>
<td>Murray et al. (1991)</td>
</tr>
<tr>
<td><em>Parapsyllus australiacus</em></td>
<td>Little</td>
<td>de Meillon (1952), Obendorf and McColl (1980)</td>
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<tr>
<td><em>Parapsyllus heardi</em></td>
<td>Rockhopper, macaroni</td>
<td>Murray et al. (1991)</td>
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<tr>
<td><em>Parapsyllus jacksoni</em></td>
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<td>Murray et al. (1991)</td>
</tr>
<tr>
<td><em>Parapsyllus taylori</em></td>
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<td>Reilly and Balmford (1975)</td>
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<td>Rockhopper</td>
<td>Dunnet (1961), Murray and Vestjens (1967)</td>
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<td>de Meillon (1952)</td>
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### Table 2. Internal parasites of penguins.

<table>
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<tr>
<th>Internal parasites</th>
<th>Penguin species</th>
<th>Part of body affected</th>
<th>Location</th>
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<td>intestine</td>
<td>Southern Australia,             Harrigan (1992), Norman et al. (1992),</td>
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<td></td>
<td>Tasmania</td>
<td>Obendorf and McColl (1980)</td>
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<tr>
<td><em>Tetrabothrius sp</em></td>
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<td>intestine</td>
<td></td>
<td>Fix et al. (1988)</td>
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<td><em>Tetrabothrius wrighti</em></td>
<td>Emperor</td>
<td>intestine</td>
<td></td>
<td>Prudhoe (1969)</td>
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<td>intestine</td>
<td>Heard Is., Kerguelen Is.</td>
<td>Prudhoe (1969)</td>
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<td>South Shetlands</td>
<td>Cielecka et al. (1992)</td>
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<td><em>Tetrabothrius joubini</em></td>
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<td>Adélie, emperor</td>
<td></td>
<td>Antarctic pack ice zone</td>
<td>Prudhoe (1969)</td>
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<td></td>
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<td>intestine</td>
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<td>Adélie</td>
<td>gastro-intestinal tract</td>
<td>Antarctica</td>
<td>Johnston and Mawson (1945), Zdzitowiecki and Drozdz (1980)</td>
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<td>Zdzitowiecki (pers. comm.)</td>
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<td>stomach</td>
<td>Macquarie Is.</td>
<td>Mawson (1953)</td>
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<td>Mawson (1953)</td>
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<td>Heard Is./Macquarie Is. captive</td>
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<td>Southern Australia</td>
<td>Mawson et al. (1986)</td>
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<td>Mawson et al. (1986)</td>
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<td>Obendorf and McColl (1980)</td>
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<td>Renicola sp.</td>
<td>Little liver</td>
<td>Southeastern Australia</td>
<td>Obendorf and McColl (1980), Harrigan (1988)</td>
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<td>Little bile duct</td>
<td>Southeastern Australia</td>
<td>Harrigan (1992), Norman et al. (1992)</td>
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<td>Family Echinostomatidae, possibly Echinostoma or Hydrodema</td>
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<td>South Shetlands</td>
<td>Zdzitowiecki (1985, 1986)</td>
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*Note: Some species are listed with multiple synonyms.*
Table 3. Micro-organisms isolated or identified through the presence of antibodies in penguins. The terms “wild” and “captive” indicate where the birds were living when the disease was manifest or evidence of disease was detected. The designation “wild-caught” indicates that the disease or infective agent was present or caught by the bird while in the wild state and that the disease became manifest shortly after the bird was taken into captivity. The identification of a pathogenic organism does not necessarily mean that symptoms of disease are manifest.

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>Disease</th>
<th>Penguin species affected</th>
<th>Wild or captive</th>
<th>Vector</th>
<th>Part of body infected</th>
<th>References</th>
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<td>Sarcocystis spp.</td>
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<td>Ippen et al. (1981)</td>
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<td><em>Plasmodium elongatum</em></td>
<td>malaria</td>
<td>Humboldt</td>
<td>wild caught</td>
<td>mosquitoes</td>
<td>parenchymal organs and blood</td>
<td>Huff and Shirbshi (1962)</td>
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<td><em>Plasmodium elongatum</em></td>
<td>malaria</td>
<td>African, Humboldt,</td>
<td>captive</td>
<td>mosquitoes</td>
<td>parenchymal organs and blood</td>
<td>Bak et al. (1984), Beier and Stoskopf (1980), Cranfield et al. (1990, 1991, 1994), Fleischman et al. (1968), Graczyk et al. (1993, 1994a,b,c), Herman et al. (1968), Stoskopf and Beier (1979)</td>
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<td>Magellanics, macaroni</td>
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<td><em>Plasmodium relictum</em></td>
<td>malaria</td>
<td>African, Yellow-eyed, rockhopper, chinstrap</td>
<td>wild</td>
<td>mosquitoes</td>
<td>parenchymal organs and blood</td>
<td>Earle et al. (1992), Fantham and Porter (1944), Fix et al. (1988), Laird (1952)</td>
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<td>Magellanics</td>
<td>wild caught</td>
<td>mosquitoes</td>
<td>parenchymal organs and blood</td>
<td>Fix et al. (1988)</td>
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<td>African</td>
<td>captive(?)</td>
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<td>Beron (1964)</td>
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<td>Fiordland, African</td>
<td>wild</td>
<td>Simulid flies</td>
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<td>Allison et al. (1978), Earle et al. (1992), Fallis et al. (1976)</td>
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<td>Babesia pierci</td>
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<td>African</td>
<td>wild</td>
<td>ticks</td>
<td>Alone, none, but may aggravate other disease, e.g. malaria</td>
<td>Brosby (1993), Earle et al. (1993)</td>
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<td>Piroplasmid, possibly</td>
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<td>wild</td>
<td>ticks</td>
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<td>Cunningham et al. (1993), Spielman and Cunningham (1993)</td>
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<td>Babesia spp.</td>
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<td>toxoplasmosis</td>
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<td>Ratcliffe and Worth (1951)</td>
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<td>Wild or captive</td>
<td>Part of body infected</td>
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<td>Newcastle disease</td>
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<td>wild-caught</td>
<td>serum antibodies</td>
<td>Pierson and Piow (1975)</td>
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<td>Newcastle disease</td>
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<td>wild</td>
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<td>wild</td>
<td>serum antibodies</td>
<td>cloacal swabs</td>
<td>Morgan and Westbury (1981)</td>
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<td>wild</td>
<td>serum antibodies</td>
<td>cloacal swabs</td>
<td>Karesh et al. (1999), Morgan and Westbury (1981), Morgan et al. (1978, 1981)</td>
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<td>captive</td>
<td>respiratory tract</td>
<td>serum antibodies</td>
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<td>captive</td>
<td>pulmonary</td>
<td>serum antibodies</td>
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<td>captive</td>
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<td>Obendorf et al. (1997)</td>
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<td>gut</td>
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<td>Bunt (1955), Soucek and Mushin (1970)</td>
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<td>wild</td>
<td>faeces</td>
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<td>Gardner et al. (in prep)</td>
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<td>faeces</td>
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<td>Oelke and Steiniger (1973)</td>
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<td>MacKnight et al. (1990)</td>
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<td>de Lisle et al. (1990)</td>
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<td>Avian cholera</td>
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<td>de Lisle et al. (1990)</td>
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<td>Lensink and Dekker (1978)</td>
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<td>Plesiomonas shigeloides</td>
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<td>Gauthier-Clerc et al. (1999)</td>
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<td>Hines et al. (1990)</td>
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</tbody>
</table>
Table 4. The cellular composition of whole blood-erythrocytes and haemoglobin. Erythrocyte count (number concentration of erythrocytes), MCH (mean corpuscular haemoglobin), MCMC (mean corpuscular haemoglobin expressed as the mass concentration of haemoglobin in erythrocytes), MCV (mean corpuscular volume i.e. volume of one erythrocyte). Haematocrit is the volume of erythrocytes in relation to the volume of whole blood. Haemoglobin concentration is given as the concentration in whole blood.

<table>
<thead>
<tr>
<th>Species</th>
<th>Erythrocyte count (x10^11/μl)</th>
<th>Haemoglobin (g/100ml)</th>
<th>Haematocrit (%)</th>
<th>MCH (pg)</th>
<th>MCHC (%)</th>
<th>MCV (fl)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adélie</td>
<td>1.90 - 2.17</td>
<td>16.2 - 17.6</td>
<td>44.4 - 50.3</td>
<td>81.6</td>
<td>35.0 - 37.6</td>
<td>235 - 239</td>
<td>Block and Murrish (1974), Clarke and Nicol (1993), Douglas et al. (1976), Guard and Murrish (1973), Milsom et al. (1973), Myrcha and Kostelecka-Myrcha (1980)</td>
</tr>
<tr>
<td>Chinstrap</td>
<td>1.91 - 2.10</td>
<td>16.6 - 19.6</td>
<td>43.0 - 52.8</td>
<td>87.2</td>
<td>35.9 - 37.7</td>
<td>224 - 243</td>
<td>Block and Murrish (1974), Douglas et al. (1976), Milsom et al. (1973), Myrcha and Kostelecka-Myrcha (1980)</td>
</tr>
<tr>
<td>Little</td>
<td>1.66 - 2.05</td>
<td>13.8 - 14.4</td>
<td>41.1 - 43.3</td>
<td>70.3</td>
<td>32.1</td>
<td>217 - 229</td>
<td>Clarke and Nicol (1993), Nicol et al. (1988), Spielman (pers. com.)</td>
</tr>
<tr>
<td>Rockhopper</td>
<td>2.36</td>
<td>16.4</td>
<td>45.0</td>
<td>36.6</td>
<td>195</td>
<td>215</td>
<td>Hawkey et al. (1989)</td>
</tr>
<tr>
<td>Magellanic</td>
<td>1.99</td>
<td>13.9</td>
<td>42.0</td>
<td>33.1</td>
<td>215</td>
<td>215</td>
<td>Hawkey et al. (1989)</td>
</tr>
<tr>
<td>African</td>
<td>1.57 - 2.10</td>
<td>14.2 - 15.4</td>
<td>42.8 - 46.7</td>
<td>70 - 103</td>
<td>32.8 - 33.6</td>
<td>210 - 315</td>
<td>Graczyk et al. (1994d), Stoskopf et al. (1980)</td>
</tr>
<tr>
<td>Chicken</td>
<td>0.72 - 3.80</td>
<td>8.6 - 13.9</td>
<td>25.5 - 40.8</td>
<td>36.0 - 41.0</td>
<td>30.0 - 40.0</td>
<td>92 - 137</td>
<td>Clarke and Nicol (1993), Hodges (1977)</td>
</tr>
</tbody>
</table>
### Table 5. The cellular composition of whole blood leukocytes.

<table>
<thead>
<tr>
<th>Species</th>
<th>Total leukocytes (x10^12/1)</th>
<th>Heterophils (10^9/1) %</th>
<th>Lymphocytes (10^9/1) %</th>
<th>Monocytes (10^9/1) %</th>
<th>Eosinophils (10^9/1) %</th>
<th>Basophils (10^9/1) %</th>
<th>Polychromatophils (10^9/1) %</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adélie</td>
<td>38.5-86.0</td>
<td>7.8-51.8</td>
<td></td>
<td>2.5-5.5</td>
<td>1.8-7.5</td>
<td>0.8-6.0</td>
<td>1.0-2.0</td>
<td>Zinsmeister and van der Heyden (1987a,b)</td>
</tr>
<tr>
<td>Gentoo</td>
<td>6.00</td>
<td>3.80</td>
<td>40.8-69.8</td>
<td>1.60</td>
<td>26.0-54.0</td>
<td>0.0-3.3</td>
<td>1.0-7.0</td>
<td>Hawkey et al. (1985, 1989), Zinsmeister and van der Heyden (1987a,b)</td>
</tr>
<tr>
<td>Chinstrap</td>
<td>56.0-67.3</td>
<td></td>
<td>27.8-43.8</td>
<td></td>
<td>0-4.8</td>
<td>0.0</td>
<td>0.0-5.0</td>
<td>Zinsmeister and van der Heyden (1987a,b)</td>
</tr>
<tr>
<td>Little</td>
<td>7.02</td>
<td>4.38</td>
<td>2.12</td>
<td>0.44</td>
<td>0.27</td>
<td>0.01</td>
<td>4.79</td>
<td>D.Spielman (pers. comm.)</td>
</tr>
<tr>
<td>Rockhopper</td>
<td>29.0</td>
<td>63.0</td>
<td>1.8</td>
<td>1.8</td>
<td>6.4</td>
<td>0.6</td>
<td></td>
<td>Hawkey et al. (1989)</td>
</tr>
<tr>
<td>Magellanic</td>
<td>32.0</td>
<td>60.0</td>
<td>1.2</td>
<td>1.2</td>
<td>6.4</td>
<td>0.1</td>
<td></td>
<td>Hawkey et al. (1989)</td>
</tr>
<tr>
<td>African</td>
<td>11.6-16.1</td>
<td>8.23-9.45</td>
<td>4.19-6.50</td>
<td>0.28-0.37</td>
<td>0.11-0.22</td>
<td></td>
<td></td>
<td>Graczyk et al. (1994d), Stoskopf et al. (1980)</td>
</tr>
<tr>
<td>Chicken</td>
<td>16.6-29.4</td>
<td>13.3-27.2</td>
<td>59.1-76.1</td>
<td>5.7-10.2</td>
<td>1.4-2.5</td>
<td>1.7-2.4</td>
<td></td>
<td>Hodges (1977)</td>
</tr>
</tbody>
</table>

### Table 6. Total protein, fibrinogen and pH levels of whole blood of penguins and the chicken.

<table>
<thead>
<tr>
<th>Species</th>
<th>Total protein (g/l)</th>
<th>Fibrinogen (g/l)</th>
<th>Body Temp (deg C)</th>
<th>pH</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gentoo</td>
<td>41.7-59.8</td>
<td>3.1</td>
<td>38.8</td>
<td>7.51</td>
<td>Aguilera et al. (1993), Block and Murrish (1974), Douglas et al. (1976), Hawkey et al. (1985), Rosa et al. (1993)</td>
</tr>
<tr>
<td>Chinstrap</td>
<td>41.0-50.6</td>
<td></td>
<td></td>
<td>7.52</td>
<td>Aguilera et al. (1993), Block and Murrish (1974), Douglas et al. (1976), Rosa et al. (1993)</td>
</tr>
<tr>
<td>Emperor</td>
<td></td>
<td></td>
<td>38.1-39.0</td>
<td></td>
<td>Boyd and Sladen (1971)</td>
</tr>
<tr>
<td>Little</td>
<td>46.3-53.3</td>
<td></td>
<td></td>
<td></td>
<td>Clarke and Nicol (1993), Spielman (pers. comm.)</td>
</tr>
<tr>
<td>Rockhopper</td>
<td>25-64</td>
<td></td>
<td></td>
<td></td>
<td>Ghebremeskel et al. (1989)</td>
</tr>
<tr>
<td>African</td>
<td>59.20</td>
<td></td>
<td></td>
<td></td>
<td>Stoskopf et al. (1980)</td>
</tr>
<tr>
<td>Magellanic</td>
<td>32.60</td>
<td></td>
<td></td>
<td></td>
<td>Ghebremeskel et al. (1989)</td>
</tr>
<tr>
<td>Chicken</td>
<td>4.36</td>
<td></td>
<td></td>
<td></td>
<td>Clarke and Nicol (1993)</td>
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</tbody>
</table>
Table 7. Normal levels of blood biochemical constituents.

<table>
<thead>
<tr>
<th></th>
<th>Adélie</th>
<th>Gentoo</th>
<th>Chins trap</th>
<th>Little</th>
<th>African</th>
<th>Rockhopper</th>
<th>Magellanic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>(mmol/l)</td>
<td>144-158</td>
<td>154-169</td>
<td>157</td>
<td>104-170</td>
<td>138-162</td>
<td>140-166</td>
</tr>
<tr>
<td>Potassium</td>
<td>(mmol/l)</td>
<td>2.8-5.3</td>
<td>1.9-4.14</td>
<td>3.46</td>
<td>2.5-15.3</td>
<td>10.3-16.7</td>
<td>2.3-20.1</td>
</tr>
<tr>
<td>Chloride</td>
<td>(mmol/l)</td>
<td>106-121</td>
<td>106-117</td>
<td>117</td>
<td>76-130</td>
<td>103-126</td>
<td>100-113</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>(mmol/l)</td>
<td>0.39-1.28</td>
<td>0.46-1.54</td>
<td>1.23</td>
<td>0.64-3.94</td>
<td>0.92-2.63</td>
<td>1.42-2.82</td>
</tr>
<tr>
<td>Calcium</td>
<td>(mmol/l)</td>
<td>2.36-3.01</td>
<td>2.18-2.76</td>
<td>2.50</td>
<td></td>
<td>1.46-3.31</td>
<td>1.84-2.43</td>
</tr>
<tr>
<td>Magnesium</td>
<td>(mmol/l)</td>
<td>0.76-1.2</td>
<td>0.86</td>
<td>0.78</td>
<td>0.48-117</td>
<td></td>
<td></td>
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<tr>
<td>Total bilirubin</td>
<td>(mmol/l)</td>
<td>7.0-19.0</td>
<td>1.0-4.0</td>
<td></td>
<td></td>
<td>1.0-5.0</td>
<td>1.0-5.0</td>
</tr>
<tr>
<td>Creatinine</td>
<td>(mmol/l)</td>
<td>7.0-40.0</td>
<td>34-43</td>
<td></td>
<td></td>
<td>29-68</td>
<td>53-83</td>
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<tr>
<td>Uric acid</td>
<td>(mmol/l)</td>
<td>125-817</td>
<td>329-1138</td>
<td></td>
<td></td>
<td>5.64-6.46</td>
<td></td>
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<tr>
<td>Urea</td>
<td>(mg/dl)</td>
<td>12.80</td>
<td>12.1</td>
<td>5.1-7.2</td>
<td>5.64-6.46</td>
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<tr>
<td>Triglyceride</td>
<td>(mg/dl)</td>
<td>81.40</td>
<td>102.3</td>
<td>66.7-89.5</td>
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<tr>
<td>Alkaline</td>
<td>(U/l)</td>
<td>22.0-171+</td>
<td>31-128</td>
<td>357</td>
<td>0.3-1093</td>
<td>176.8-210.2</td>
<td>28-176</td>
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<tr>
<td>Phosphatase</td>
<td></td>
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<td></td>
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<tr>
<td>GGTP</td>
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<tr>
<td>ALT</td>
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<td></td>
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</tr>
<tr>
<td>Glucose</td>
<td>(mmol/l)*</td>
<td>12.4-17.6</td>
<td>13.1</td>
<td>15.4-19.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>References</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Aguilera et al. (1993), This study</td>
<td></td>
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</tr>
<tr>
<td>Aguilera et al. (1993), Ghebremeskel et al. (1989)</td>
<td></td>
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<tr>
<td>Aguilera et al. (1993), Ferrer et al. (1994)</td>
<td></td>
<td></td>
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<tr>
<td>D.Spielman (pers. comm.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Graczyk et al. (1995)</td>
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<tr>
<td>Ghebremeskel et al. (1989)</td>
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<tr>
<td>Ghebremeskel et al. (1989)</td>
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<td></td>
</tr>
</tbody>
</table>

* conversion factors used to convert values for glucose and cholesterol from mg/dl to mmol/l were 0.0555 and 0.0259 respectively.
A visit to the South Shetland Islands, c. 1820

The South Shetland Islands, setting of the excerpt below, are about 800 km (500 miles) southeast of Cape Horn, between the Falkland Islands and the Antarctic Peninsula. They were found in 1819 by William Smith, a sealing boat captain looking for new supplies of fur seals to be killed for their skins. Despite the vast numbers of seals, and the harsh conditions under which the sealers worked, the seal populations of most islands were nearly gone within a few years and the ships then searched for even more remote islands. The accounts here are from William Smith’s writings, and from the logbooks of another sealboat captain, Robert Fildes.

William Smith had said that the beaches were as good as paved with guineas [gold coins], such was the number of seals, and so valuable their skins. The seals took no notice of the sealers killing their neighbours, and ‘regarded a man as no more than they did a bird’; [Captain] Fildes found that ‘going amongst these unconcern’d creatures put me in mind of Adam when surrounded by the beasts of the field at the time of the Creation.’

He also tells of the immense numbers of penguins, both Macaronis and Adélies—‘half form’d birds’ he calls them. After the loss of the Cora the crew built a tent ‘with sails and other materials, on the ground—part of which consisted of four lines of puncheons [large barrels] in form of a square, the heads of the inside ends being taken out so that two men could stow in and sleep, both warm and dry. One of these which was to spare was taken possession of by the [ship’s] cat, and two penguins one day came up out of the water and took up their station alongside her in the cask, they neither minding the people in the tent nor the Cat, nor the Cat them, poor shipwreck’d puss used to sit purring alongside them apparently comfortable and pleased with their Company. These penguins used to go to sea for hours and as soon as landed again would make direct for the tent and get into the cask. The crew would sometimes, to plague them, endeavour to keep them out by keeping the tent shut, but they always found a way to get in by getting under the canvass; in this manner did they stop with us until we left the coast.


---

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Enquiries/More Information: adu@maths.uct.ac.za
Prevention and treatment of avian malaria in a captive penguin colony

For more than a decade, the San Francisco Zoo has kept a colony of Magellanic Penguins (*Spheniscus magellanicus*). They have bred consistently; offspring were recently sent to the Oceanário do Lisboa (Lisbon, Portugal). The penguins are kept in an outdoor exhibit year-round. The major health problem for this colony has been mosquito-borne avian malaria (*Plasmodium relictum* and *P. elongatum*). Since 1997, 17 of our adult Magellanic Penguins, of various ages, have shown clinical signs of malaria. Four birds died immediately in the acute (tissue) phase. Ten birds were treated and recovered. Three birds died despite treatment, but each of them also had complications with aspergillosis.

This article summarizes the prevention and treatment measures we have adopted, based on our experience. We have had a number of enquiries from other zoos about aspects of our protocol, and we are publishing it now not because we think it is perfect, or even in its final stages—this sort of thing is always refined in the light of new observations, or new medications. But we hope parts of it may be useful to others, and that its publication may promote further discussion in these pages, to the benefit of all.

**GETTING STARTED**

Prepare for malaria, rather than waiting for an outbreak. This article describes management and husbandry techniques which, in our experience, have been crucial for prevention and treatment. These take time to implement, and may involve increased staff time, but our experience has been that they are essential for early detection and effective medication. In the long run, these techniques and routines will contribute to better overall health of the colony even if malaria never strikes.

1. **Animal care consistency**
   - The same keepers should be taking care of the birds on a regular basis. Daily notes should be made about behavior, appetite, and other outward signs of health. If the originals are forwarded to supervisory staff, keepers must keep copies for their own use.
   - Good communication between the keepers is essential, since things can change drastically from morning to afternoon.

2. **Handfeeding**
   - Whether you choose to feed in the water or on land, the penguins must be fed individually and individual intake recorded (see item 4 below). This provides the control needed for giving medication (and regular vitamins as well), and if a bird goes off its feed you will know immediately. Each penguin must be easily identifiable with flipper tags, removed during molt if necessary. These birds must be treated as individuals rather than as a colony. Naming the birds as well as identifying personalities is imperative; it aids memory, and changes keepers' awareness of the birds so that it is individual-based rather than group-based.

3. **Train the birds to hand-feed**
   - Choose the most tractable birds, in a healthy colony, and begin giving them fish by hand, then move quickly—over two or three days—to feeding all birds by hand only. Patience is the key here. Continue to go out to feed at the regular time and try and coax the hesitant birds to eat from you. Our experience has been that all will adapt when they become hungry enough. Healthy penguins can fast for up to one week without harm.

   N.B.: This can only be done during "mid-season," the period after moult and before breeding season, since this is the time of least stress on the colony.

   Begin early enough that you will have plenty of time and not have to give up partway through, due to the approach of breeding.

4. **Develop a feedsheet**
   - Keeping daily records of fish intake and medication dispensed will help you assess the feeding habits of each bird throughout the year. [Figure 1 shows the feedsheet currently used at the San Francisco Zoo. Look for signs of appetite loss every day, and monitor your birds closely.

   Depending on the size of the colony, you may need a second person at each feeding, with a clipboard and a quick eye, to record how much each bird eats and whether each one ate its special vitamin or medicine fish. If staff are not available, volunteers can help out as long as they commit to helping regularly so that the penguins know them and vice versa.

**MALARIA SYMPTOMS**

1. **Acute (tissue) phase**
   - In this stage, birds show lack of coordination, ataxia, stumbling and circling behaviors. Major upper respiratory distress follows. No amount of supportive care seems to have any effect on the bird when it is in this phase. For our birds, if this phase is going to be fatal death usually occurs within 24 to 36 hours. But, as evidenced by our survival statistics cited above, most birds are able to pass through this phase and go into the next, which we refer to as the "blood phase."
2. Blood phase

There are several signs to look for. Sick birds may show all or some, though occasionally there are no observable signs.
- Loss of appetite (even if only for a single day).
- Green stool. It is a milky pale green, not bile green and not fluorescent green as in aspergillosis. The color is very close to that of mint chocolate chip ice cream (your local ice cream may vary!).
- Pale tissue, rather than the normal pink, around eyes, in the mouth, and sometimes on the feet.
- Lethargy.
- Isolation.
- Floating nearly motionless in pool, eyes semi-closed.
- Weight loss.

FACILITIES AND MEDICATIONS NEEDED

1. An isolation or holding area

Every attempt should be made to treat sick birds on exhibit. Occasionally that is not possible, and then it is necessary to have an off-exhibit enclosure, equipped with a small pool, to house birds that cannot be reliably caught and treated on exhibit. If an individual is pulled from the exhibit, always pull its mate or companion with it. Avoid trouble in the future; keep other birds from taking their nest by blocking the burrow entrance with a rock or a board.

2. Medications to keep on hand, and dosages

The following dosages are those we use with our Magellanics and we consider them appropriate for birds weighing between 2.7 and 5.4 kg (six to twelve lbs).
- Chloroquine, 12.5 - 15 mg/kg, once daily for 10 days (treats the blood phase).
- Primaquine, 0.75 - 1.0 mg/kg, once daily for 10 days (treats the tissue phase).
- Pyrimethamine, 4 mg combined with Sulfadiazine 125 mg, given once every two days in spring and summer.

Consult your vet or a human physician to find a reputable pharmaceutical compounding company to make up the doses. Treatment with pyrimethamine and/or sulfadiazine should be stopped ten days before breeding/laying season starts. Pyrimethamine is teratogenic.
- Subcutaneous fluids, 2.5% Dextrose and 45% NaCl solution. The dose is 200 – 300 cc once or twice daily, for fluid replacement in a bird weighing 2.7 - 5.4 kg (six to twelve lbs).
- Fluconazole, 100 mg once daily, as an aspergillosis prophylaxis.

PREVENTION

1. Mosquito abatement

Get rid of standing water in or near the exhibit. Stagnant pools which cannot be eliminated may be treated with mineral or vegetable oil to kill mosquito larvae, if it can be done without harming native birds and wildlife. Chlorine bleach does not kill the larvae.

Encourage mosquito-eating wildlife (e.g., provide nest boxes for insectivorous birds or put up roosting boxes for bats).

Stress

If the colony has experienced malaria in the past, minimize handling and other causes of stress during malaria season.

Prophylactic medications

During malaria season, give the combination of Sulfadiazine and pyrimethamine every other day. We use the dosage given above (in the section on medications to keep on hand).

NOTE: Sulfadiazine can cause diarrhea, and pyrimethamine can cause birth defects. Discontinue their use ten days before breeding/laying season starts. You can resume both once the eggs are laid, although we do not give prophylactic medication to parents raising chicks due to concerns about the medication being regurgitated when feeding the chicks and possibly causing an overdose. Note that this is a conservative approach. If we felt that the risk of exposure to malaria was high at a particular time then prophylaxis to the parents would be resumed.

If a penguin shows clinical signs of avian malaria, stop giving the prophylactic (preventative) medications to that bird and begin the chloroquine/primaquine treatment. A bird should never be on both regimes—prophylactic and treatment—at the same time.

If sulfadiazine/pyrimethamine is unavailable, primaquine alone may be used as a prophylaxis. We use the dosage 0.75 – 1.0 mg/kg, once daily.

Chloroquine/primaquine has also been used as a prophylactic, at treatment dose but given only once a week.

At this time no medical prophylactic treatment has proven to be 100% effective in preventing avian malaria, but in our colony the use of Sulfadiazine/Pyrimethamine has reduced the number of cases seen each year.

In humans, it is believed that taking vitamin B1 may reduce the chance of being bitten by a mosquito—by making the prospective host taste or smell bitter to biting insects. B1 may help keep mosquitoes away from penguins too, and this dose has no known harmful effects. During malaria season, we increase the usual supplement of B1 to 500 mg per bird daily. Give 750 mg B1 to each parent feeding young.

MALARIA TREATMENT

1. When malaria signs appear

If malaria is suspected (see symptoms list above), immediately put the symptomatic bird on chloroquine/primaquine (see dosage on supply list). Treat every day for ten days. If you miss a dose, do not double the dose the next day, but extend the treatment for a longer period. During the time a bird is being treated with chloroquine/primaquine it should not be given sulfadiazine/pyrimethamine.
2. Forcible medication

If a sick bird is unwilling or unable (too weak, no appetite) to take pill feed from your hand, it must be caught up once a day to be medicated. If it is not possible to catch and treat the bird consistently on exhibit, you may need to remove it and its mate or companion from the exhibit for the duration of the treatment course. Never keep a penguin by itself. Isolation is stressful and may cause the bird to lose heart and decline.

3. Force-feeding and rehydration

If you must catch the bird in order to force-feed the medication and/or fish, consider administering subcutaneous fluids at the same time. Dehydration further weakens the bird, and can itself cause death.

Extra fluid is probably unnecessary if the bird is eating on its own, and not regurgitating. If you suspect that the bird will regurgitate the fish, place the pill well down the throat, then push it down further with the small fish. Regurgitation is a side effect of both malaria and the medication, so don’t panic. Just try and get the medication into the bird as consistently as possible, and provide supportive fluids and food.

4. Blood tests and handling

Diagnosis of malaria can be made by finding the parasite organism in blood smears. However, due to the short potent period of the organism in the blood and the fact that the organism can be misidentified, this method can be unreliable. An easy accurate test for malaria can now be made with the use of a malaria Plasmodium ELISA test on blood samples (Anilab, Baltimore MD). This test is used as a screening test for exposure only: it cannot tell you if a positive result is due to active infection or past infection.

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**Comments**

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<th>Season</th>
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<tr>
<td>CLP = chloroquine primaquine</td>
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<tr>
<td>SPY = sulfadiazine + pyrimethamine</td>
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<td>F = fluconazole</td>
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<td>B = Vitamin B1</td>
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Directions: Record each bird’s consumption of vitamin fish and plain fish in the appropriate column, for AM and PM feedings. When medications are given successfully, circle the initials. Daily totals are for AM and PM, separated by a /.

Figure 1. Sample Penguin Feeding Data sheet, slightly reduced in size. Medication initials are entered by hand to indicate which birds are to receive which medications. This sample shows that Penguin #25 ate 1 vitamin fish with CLP (medication) and 4 plain fish in the am feeding. #152 did not eat in the AM, but in the PM ate 1 vitamin fish with SPY (medication) and 2 plain fish. #10 ate a vitamin fish in the morning feeding, but did not get its scheduled dose of F. Records such as this help the feeder keep track while feeding, schedule missed medications for the next feeding, support the keepers’ “feeling” that one or more birds are eating less than usual for the season, and provide data for long-term and comparative studies.
Handling a sick bird as little as possible is extremely important because stress seems to accelerate the progression of the malaria.

Our current approach, therefore, is to start treatment immediately when a bird shows signs of malaria. If we feel that diagnostics such as bloodwork and x-rays are indicated, these are performed only after 3-4 days of treatment.

If you can do in-house Packed Cell Volume tests (PCV), that will give you some useful information while you wait for other results. Normal PCV range for our Magellanic Penguins is 45-55%. In cases where the PCV fell into the 10-20% range, a blood transfusion from a healthy donor has assisted in giving the support necessary to respond to treatment.

X-rays will not show anything specific to diagnose malaria, but will eliminate other concerns such as foreign objects or aspergillosis.

5. Preventing opportunistic aspergillosis

In addition to the combination of chloroquine/primaquine for malaria, we recommend giving the sick bird fluconazole, 100 mg once daily, to protect against possible aspergillosis. The likelihood of aspergillosis occurring is greater in a compromised bird.

6. When the treatment course ends

At the end of the 10-day treatment, assess whether the bird is still sick, and if not, whether it is ready to return to the colony. In one case among our penguins, another 10-day treatment was needed before the bird responded.

If the bird is sufficiently improved, return it and its mate back to the colony. If the bird has contracted malaria early in the season then start it back on malaria prophylaxis along with the rest of the colony.

In general, we feel that the stress of catching a bird just recovered from malaria, in order to force-feed and medicate it, is not justified and may result in the bird refusing to hand-feed for a long time to come. Give the bird a chance to get hungry and forget its recent ordeal at your hands. Once the recovered bird has returned to the colony, let it come to you. After so much handling, it will be very wary of humans.

If the bird is not eating, wait 3 – 4 days before trying to force-feed again.

When a bird has gone 3 – 4 days without eating, additional subcutaneous fluids must be given.

If, at the end of its off-exhibit treatment, a bird is down in weight, and not taking fish from your hand willingly, it may need to be kept off-exhibit an extra couple of days and led to regain some strength and weight.

ACKNOWLEDGEMENTS

We want to thank the following for their input in helping us develop our protocol: Michael Cranfield, DVM, Baltimore Zoo (Maryland); Tom Reidarson, DVM, Sea World San Diego (California); Freeland Dunker, DVM, San Francisco Zoo (California). Dr. Dunker also provided the veterinary specifics for this article and reviewed it prior to submission.

A few recollections from Scott’s Antarctic Expedition in 1910

Polar exploration is at once the easiest and most isolated way of having a bad time which has been devised... There are many reasons which send men to the Poles, and the Intellectual Force uses them all. But the desire for knowledge for its own sake is the one which really counts and there is no field for the collection of knowledge which at the present time can be compared to the Antarctic. Exploration is the physical expression of the Intellectual Passion. And I tell you, if you have the desire for knowledge and the power to give it physical expression, go out and explore. If you are a brave man you will do nothing: if you are fearful you may do much, for none but cowards have need to prove their bravery. Some will tell you that you are mad, and nearly all will say, 'What is the use?' For we are a nation of shopkeepers, and no shopkeeper will look at research which does not promise him a financial return within a year. And so you will sledge nearly alone, but those with whom you sledge will not be shopkeepers: that is worth a good deal. If you march your Winter Journeys you will have your reward, so long as all you want is a penguin's egg...

We had bad winds at Cape Evans this year, and we had far worse the next winter when the open water was at our doors. But I have never heard or felt or seen a wind like this. I wondered why it did not carry away the earth.

It was not until I got out of the tent one morning fully ready to pack the sledge that I realized the possibilities ahead. We had had our breakfast, struggled into our foot gear, and squared up inside the tent, which was comparatively warm. Once outside, I raised my head to look round and found I could not move my body. My clothing had frozen hard as I stood, in perhaps fifteen seconds. For four hours I had to pull with my head stuck up, and from that time we all took care to bend down into a pulling position before being frozen in.

—A. Cherry-Garrard, the youngest member of Scott's team, wrote The Worst Journey in the World about a journey, on foot, to being back an emperor penguin egg for scientists.
1998 Japanese regional studbooks for gentoo and Humboldt Penguins

Gentoo penguin
The first edition of the Japanese Regional Studbook for the gentoo penguin (*Pygoscelis papua*) was published in November 1999, by the Port of Nagoya Public Aquarium. The Studbook Keeper is Masanori Kurita.

This population is based on birds brought into Japan from the Edinburgh Zoo and the Basle Zoo, and 28 birds collected as eggs from the South Shetland Islands in 1990. Since the place of origin of each of these founding groups is known, the studbook classifies the living population by sub-species based upon that information. Those from the Edinburgh Zoo originated in South Georgia, and are classified as *P. p. papua*; those from the South Shetlands, as *P. p. ellsworthi*, and the Basle contingent, which was based on Edinburgh birds and one specimen of unidentified origin, are treated as an unknown subspecies. No gentoos have been imported into Japan since 1995.

As of June 30, 1999, ten zoological institutions in Japan housed a total of 149 gentoos. At two institutions, there were mixed populations of gentoos belonging to known and unknown sub-species. No hybrids have been produced.

In 1998, 23 chicks hatched, of which 18 survived past 30 days. By sub-species, the hatches were: 17 *P. p. papua*, and six *P. p. ellsworthi*; there have been no hatchings to the unknown sub-species groups since 1997.

[Editor, based on data from studbook]

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Humboldt Penguin

On December 31, 1998, this population consisted of 1440 individuals (443-460-637) at 78 institutions. There were 229 chicks hatched at 43 institutions during 1998, of which 98 died before 30 days, for a hatching survival percentage of 57%. Most of the chicks (199) were parent-reared, with 14 being hand-reared, 14 foster-reared, and two for which information is not available. This species often has low survival rates for parent-reared offspring, as in this case, with 58% survival for parent-reared, and 92% for hand-reared, chicks.

[Editor, based on data from studbook]

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Japan


Both the 1998 and 1999 editions are in hand and will briefly be summarized here.


During 1998, there were 16 hatchings, 18 deaths, no exports and eight imports. The eight birds imported included six offspring of wild-caught parents, coming from zoological institutions at Dresden and Schwerin.

In 1999 there were no imports or exports, 12 hatchings and 17 deaths.

High mortality among parent-reared chicks aged <30 days remains an intermittent problem for this species in zoological institutions. Chick survival rates for the three years preceding 1998 (in North America) were about 80%. But in 1998 seven of 16 hatchlings died at <30 days of age, giving a survival rate of 56%. The reported rearing methods were: parent-rearing, used for 13 chicks; foster-rearing, two chicks; unknown, one chick; and hand-rearing, none. One death was of a foster-reared chick and the rest were parent-reared.

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<td>1999</td>
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Table 1. Data for North American Humboldt penguin population, as of 31 December in each year. From 1998 and 1999 studbooks and SSP Reports.
Penguins group up in cloudy weather

**TITLE:** A note on swimming group size in captive African penguins (*Spheniscus demersus*) in relation to weather conditions.

**AUTHOR:** Mori, Yoshihisa

**AUTH. ADDRESS:** Dep. Zool., Grad. Sch. Sci., Kyoto Univ., Kitashirakawa, Sakyo, Kyoto 606-8502, Japan


**ABSTRACT:** The author studied the swimming group size of captive African penguins in relation to weather conditions at Ueno Zoo in Tokyo. The occurrence of swimming behavior did not vary between fair and cloudy conditions. However, under cloudy conditions the birds synchronized the timing of swimming with each other, and swimming group size increased. Group size may covary with predation risk and function as an antipredator response in the wild.

**INDEX TERMS:** behavior; birds; environmental factors; flocks; swimming; weather; African penguin

New bio-mechanical device removes oil from bilge water

*The pumping of oily water from bilge tanks is a common cause of oil pollution in the sea, in small localized amounts. It is believed to be the cause of some or most of the oiling suffered by Magellanic penguins off the coast of Argentina.*

The Great Lakes cargo vessel MV *James R. Barker* recently completed successful sea trials with the first maritime bio-mechanical oil water separator for the treatment of oily bilge water.

The 1,000-ft. ore carrier, owned by Interlake Steamship Company, Cleveland, Ohio, is the first to be equipped with the PetroLiminator 630 oil water separator system, developed by EnSolve Biosystems, Inc., Raleigh, North Carolina. The PetroLiminator 630 was installed on the ship in March, and has been in continuous operation since. *[This article appeared on 19 July 2000]*

The patented PetroLiminator 630 uses bioremediation to treat bilge water to meet international clean-water standards for discharge into environmentally sensitive waterways.

Safe, non-pathogenic hydrocarbon-ingesting bacteria convert oils (including synthetics), grease, detergents and other hydrocarbons into harmless end products. An oil content monitor continuously tests the clean effluent prior to discharge.

The PetroLiminator 630 was type-approved by the U.S. Coast Guard earlier this year as meeting the IMO-specified regulatory limit of 15 parts per million. The automated system works 24 hours a day, processing up to 20,000 gallons of bilge water per week.

Michael Johansen, Relief Chief Engineer of the MV *James R. Barker* said, “The effluent has been consistently far below the regulatory limits. I no longer have to worry about the condition of the overboard effluent from the oily water separator.”

Interlake Fleet Superintendent Charles Minton stated, “We had trouble with oily water separators in that they’re very labor intensive, requiring the changing of filters or membranes, but the Petro-Liminator is relatively maintenance free.”

“We’ve gotten oil in our bilge water effluent down to two and even one part per million,” he added.

Based on the successful installation on the James R. Barker, Interlake expects to purchase at least two more PetroLiminator systems later this year, according to Minton.

EnSolve Biosystems is an early-stage biotechnology company based in the Research Triangle region of North Carolina. It has received numerous awards and financial support from the North Carolina Biotechnology Center for research and development. EnSolve’s other products for the marine market include bioenzymatic degreasers and oil-spill clean-up products.

The company’s website is <http://www.ensolve.com/>

The Treasure oil spill: the results, the event, the background

CYNTHIA CHENEY

The fact of the Treasure oil spill near Cape Town must by now be known to all our readers.

This article will summarize the impressive efforts to limit injury to penguins; present some details—mostly drawn from Lloyd’s of London reports—about how Treasure met her end; and then look into the background of the ship in an effort to put this event into a larger context. Disasters such as this one are not frequent, but neither are they isolated chance events. In order to reduce the occurrence of oil spills, we must look back farther than the point at which a given ship was damaged, or sank. This article offers some of that background information as a service to readers who want a better understanding of the event, but makes no pretense of having the complete story or expert knowledge.

The oil and the penguins

The bulk freighter Treasure foundered and began leaking oil on 23 June 2000 near the largest and the third largest breeding colonies of the threatened African penguin (Spheniscus demersus), at the peak of the breeding season. The potential damage was staggering. More than a third of the total population of the species was threatened by the oil. But rising to the challenge were the Southern African National Foundation for the Conservation of Coastal Birds (SANCCOB) and 40,000 volunteers, as well as many other agencies and companies which helped with transport, equipment, expertise, and financial donations.

It would be impossible to name all the groups that helped, as the list would surely fill several pages. Among the large South African organizations and agencies involved were the Department of Environmental Affairs and Tourism, Cape Nature Conservation, South African National Parks, Robben Island Museum, South African Defence Force, and the University of Cape Town; countless local conservation and birding groups helped too. Many international organizations gave substantial support, including the World Wildlife Fund, BirdLife International and its partners, and dozens of others. The International Fund for Animal Welfare took a strong role early on, flying in more than 40 experienced individuals from around the world to help with the enormous technical, logistical, and training requirements for an impromptu effort involving 83,000 birds (half of them featherless).

The majority of the volunteers were of course South Africans, but many people came from overseas to help. Among this international group were zoo staff and field researchers. They were a small percentage but very valuable because of their hands-on experience with penguins (including restraint, force-feeding, and quickly evaluating the condition of a bird), and experience in training others in these skills.

This must have been the largest bird rescue effort ever made: about 43,000 penguins were caught up. “At one stage, SANCCOB had approximately 12% of the global population of the species in a single warehouse.” (7) After the oiled birds had been cleaned—some required a dozen washings—they had to be cared for until their waterproofing and general health were satisfactory. The last bird was washed on 6 August 2000, six weeks after the spill.

A little over half of the penguins caught up had been oiled, and the rest were captured as a preventive measure before they could get into the oil. The unoiled birds were trucked to Port Elizabeth to swim home while the oil was being cleaned up. Thousands of chicks were also caught, to be hand-reared while their parents were gone.

There is no way to keep “in practice” for an event of this magnitude that happens unpredictably perhaps once in ten years. But SANCCOB deals daily with oiled seabirds, a few at a time, which have gotten into small amounts of oil perhaps pumped illegally from bilges, as well as with the larger events: pipeline breaks and shipwrecks.

Before this June, the largest oil spill they had dealt with was the Apollo Sea spill in June 1994 (1,2,3,4,5,6). That spill brought 10,000 oiled African penguins to SANCCOB, of which about 5,000 survived to be released; the high death toll resulted mostly from birds dying of the toxic effects of the oil before they could be cleaned.

The survivors were banded, and studies have shown that their mortality rates since the spill have been normal, not elevated as might be expected from the exposure to this toxic substance. Some have bred with success. (One of these studies of Apollo Sea survivors, by A.C. Woolfard et al., was reported on at the Fourth International Penguin Conference (8); earlier results were given by P. Whittington. (1)

Some of the penguins oiled in the recent Treasure spill had been banded in the past and records kept on their breeding success; in the future it will be possible to compare a penguin’s breeding success before and after being oiled. (8)

Lessons learned from the Apollo Sea experience (16) and use of recently-developed veterinary procedures resulted in a much higher survival rate this time—well over 90%.

This is a great success story for SANCCOB and everyone who participated. They would be the first to agree that a disaster prevented is infinitely better than a disaster well handled. Perhaps a closer look at the events, and Treasure herself, will shed some light on prevention.

The sinking

Unless otherwise noted, all the details following about the events involving Treasure between 15 June and 25 July of this year are based upon reports made to Lloyd’s of London by their local representatives. These reports are publicly available on the web (9). Use of the information from Lloyd’s and from other
agencies and organizations is meant to increase public understanding and knowledge of this aspect of marine pollution in general, and of the Treasure spill in particular.

Treasure sank on 23 June 2000, as a consequence of damages suffered on 14 June or earlier, while at sea. She was travelling between Brazil and China with all holds full of iron ore. The first communication to Lloyd’s states that the ship’s hatch covers had blown off in heavy weather about 750 nautical miles west of Port Nolloth (on the southwest African coast), that the No. 4 hold was flooded, and that the ship was making nine knots (17 kph, 10 mph) in an easterly direction. A tug was dispatched at full speed to escort the damaged ship.

On 20 June, Captain Dave Colly of the South African Maritime Safety Association (SAMSA) examined Treasure from the air. According to the Lloyd’s report, “Capt. Colly said that water could be observed washing in and out through a large hole in the side and that the damage appeared to be due to metal fatigue. ‘She can survive with one hold flooded but not more than that, these ships go down like stones,’ he warned. Colly said the vessel now had such a deep draught that the ship was too low in the water to enter the Cape Town harbor. The barge and equipment arrived 29 June or before, but the weather often delayed work. Winds of 90 kph (56 mph) were reported, with 10 m (33 ft) swells at the surface. Water surged dangerously in and out of the wreck, threatening divers and probably scouring out oil from the ship. By 25 July when the operation was declared complete, crews had pumped only about 220 tons of oil. It was estimated that the rest of the oil—1250 tons or more—had escaped, with pos-

search and rescue to stand by, and then proceeded to a limit line 50 miles off the Cape coast. An inspection was attempted but could not be carried out due to severe weather conditions.

It seems likely that the ship was suffering further damage all this time, as her own movement and that of the water inside No. 4 hold would flex and stress the damaged hull and the interior bulkheads.

After the attempted inspection failed, the ship was permitted to anchor “just off the port of Cape Town” where an inspection “revealed a hole in the starboard fourth hold some 10 m high by 19 m long (33 by 62 feet).”

SAMSA gave an ultimatum, that the ship’s 1300 tons of fuel oil must be removed from her tanks by noon on 22 June, or else the ship could not remain in South African waters.

This condition was not met—according to the Lloyd’s report, because of “complex and time-consuming insurance negotiations.” Participants in such negotiations would probably include not only representatives of the owners and the various insurers of the ship, but those of the cargo owners too.

Now the maritime authority faced a thorny decision, what to do about this ship which was anchored not in the harbor proper, but near its entry, and very near Robben Island (only four miles away, according to a summary of events in the 26 June report to Lloyd’s). Captain Colly had been of the opinion that the ship was too low in the water to enter the Cape Town harbor but no further discussion of this was found while researching this article. The decision was made: SAMSA ordered Treasure “out of its waters because she posed a potential major pollution hazard as she had begun to sink.”

With a tug escorting her, the ship got under way at 3:17 PM on 22 June, in heavy seas, but two hours later could no longer proceed and was “prepared for a dead tow” by the tug. The tow began at 6:17 PM, after the captain and remaining crew had been taken off. About 10 PM, Treasure was 16 km (10 mi) NW of Robben Island when the tow connection parted and she began to sink more rapidly. Attempts to re-attach the tow rope were frustrated by “adverse weather conditions and because much of the bow was under water.” The ship, mostly under the water but not on the bottom yet, drifted east at about 1 knot per hour (1.9 kmh, 1.2 mph) until nearly 4 AM when she settled on the bottom in about 50 m (164 ft) of water. Later surveys indicated that the ship had suffered severe additional damage when she sank.

From this point on the carcass of Treasure was continually attended by salvage company vessels. While waiting for the arrival of a container barge into which the oil could be pumped, and specialized equipment on its way from Rotterdam, the salvage company wanted to get divers down to assess the situation, inspect all of the oil tanks, and seal off leaks. But the very strong winds and heavy seas frequently prevented the divers from working.

Before abandoning ship the crew had sealed some but not all of the air vents on the fuel tanks. Oil was observed coming out of these vents, and divers sealed them off with plastic bags until permanent metal covers could be attached. The bags broke at least twice, allowing more oil to leak out. There may have been much larger leaks also; new oil kept washing onto various beaches, and some drifted down to Dassen Island, 48 km (30 mi) away, where the largest breeding colony of African penguins is located.

The barge and equipment arrived 29 June or before, but the weather often delayed work. Winds of 90 kph (56 mph) were reported, with 10 m (33 ft) swells at the surface. Water surged dangerously in and out of the wreck, threatening divers and probably scouring out oil from the ship. By 25 July when the operation was declared complete, crews had pumped only about 220 tons of oil. It was estimated that the rest of the oil—1250 tons or more—had escaped, with pos-

please turn to page 36
Fire fighting equipment: Several fire hoses were dry-rotted, and leaked excessively when tested under pressure.

Ship: *Avra*

Fire fighting equipment: Engine room fire hoses were severely deteriorated and leaked excessively under pressure.

Launch arrangt. for survival craft: Lifeboat davit sheaves were seized *(frozen in place, inoperable)*.

Other (Safety In General): The cargo hatch hydraulic motors were leaking excessively, resulting in hazardous amounts of oil on the main deck. (13)


In 1998 the Good Faith company was named one of the twenty worst shipping companies in the world in a list put out by the world’s largest maritime labor organization, London-based International Transport Workers’ Federation *(ITF)*. (10) The ITF is a federation of the world’s transport workers’ unions, representing more than five million workers in 120 nations.

As a union, the ITF’s points of criticism center on matters related to the crew, rather than things like training or condition of equipment. The ITF’s list of complaints about Good Faith’s ships is as follows:

“Substandard accommodation, low wages, basic monthly wage for Able Seamen *(Ab)* USD 266. Wages outstanding for up to six months. Unfair dismissal claims. Crew threatened through the manning agents which employ them—particularly Chinese and Moldavian (threatened with imprisonment) and Ukrainian (threatened with physical violence).” (10)

It would seem that big commercial ships, frequently entering large ports in many countries, would be under the eye of those who enforce regulations, and hence kept to the standards. Maybe this would happen if the system were simpler. The regulatory system for maritime vessels is extremely complex, involving various insurers, “classification societies” (19), inspections at ports of call by port authorities such as the Coast Guard or SAMSA, inspections by the country of registration, and international laws, treaties, and agreements. It is intended that a large role will be played by the country in which a ship is registered, known as the Flag Country since the ship flies that flag.

Ship owners may choose to register their ships in certain countries where taxes are low or non-existent. In many of these countries laws about wages and working conditions are absent, and enforcement of regulations is lax. These registrations are known as Flags of Convenience, and the countries which issue them, are FOC countries.

The “flag country” of a ship is supposed to regulate (and enforce or oversee) things such as how often regularly scheduled drydock examinations should occur (20). It is supposed to conduct inspections of equipment, mechanical soundness, and fire control systems; see that annual and other training is effectively carried out, that exercises such as lifeboat training, maneuvering performance tests, and so on are carried out... the list goes on and on. Some FOC countries take these responsibilities seriously, but many do not, and this is an attraction for certain shipping companies.

Part of the regulatory structure is based on laws of the flag country itself, and much of the rest on international maritime agreements that the country has signed. But the international agreements only apply to countries that have signed them, and many of the FOC nations have not.

Of the world’s 83,000 commercial ships, fewer than 20% fly a flag of convenience, yet “FOC shipping represents more than half of worldwide ship losses.” (21) FOC ships also account for a disproportionate share of marine pollution and illegal fishing. (15)

Good Faith Shipping is based in Greece and has registered 30 of its 43 ships in
Panama, an FOC country. According to the ITF, Panama is
"...the 'Number One' deficient flag state in the world. Panama earns around US$20 million a year for selling its flag, but it takes none of its responsibilities as a flag state seriously... In 1997 alone, Panama lost more ships and more tonnage than any other flag state. It also boasts the highest number of port detentions [in other countries' ports], the highest deficiencies in certification, safety, navigation, pollution and operations, of all flag states." (12)

The two ships mentioned earlier which collided, Las Sierras and Halo Cygnus, were both registered in Panama. (12)

"FOC" shipping companies are free to offer low wages and bad working and living conditions, and recruit less skilled crews from poorer countries. Living conditions aboard some vessels are so wretched they have been described as "Dickensian". (18)

There is often no effort to make up a crew of mostly the same nationality to lessen language problems. The Maritime Union of Australia notes that "like national flag fleets, Flags of Convenience vessels are registered or flagged in one country, owned in another, managed in a third and crewed in a fourth." (12) As a result "most seafarers must speak a foreign language when at work." Only 30 per cent of seafarers serve on vessels with a crew of the same nationality, according to an ITF survey. (17)

This practice has some clear advantages for avoiding regulation. Such crews may be less likely to know regulations about safety, or about working conditions, and much less likely to complain to anyone. Language differences can also be a handicap in detailed exchange of information, crew training, and quick response to orders.

Good Faith Shipping Co. draws their crews from Greece, The Philippines, Maldives, Egypt, Honduras, Poland, Ghana, and the Ukraine. (10) The crew of Treasure was Chinese and they were reportedly flown home after the ship sank.

Because of failure on the part of owners and flag countries to fulfill their supervisory and regulatory duties, the following conditions can result:
- Ships and equipment are poorly maintained
- Officers and crew are not adequately trained in use of equipment, safety procedures, and relevant regulations
- Crew efficiency may be impaired by poor working conditions and language differences
- Decisions may be made which are dangerous or illegal, because economic factors are more valued than safety and adherence to regulations

Maritime authorities agree that when such conditions exist, they result in higher accident rates—as opposed to the common image of shipwrecks resulting from severe weather or other 'acts of God'. Even when damage occurs as a result of wind or weather, maintenance and operational decisions can be a factor. When an emergency occurs, how well it is handled will depend upon the training and expertise of officers and crew, and the fitness of the equipment.

"Statistics compiled by the Institute of London Underwriters on global ship casualties [in 1996] indicate that ship losses in general were up for the first half of 1996. The Institute cites aging vessels, coupled with poorly trained crew and inadequate maintenance as the reasons. Not suprisingly, these same concerns were noted by West Coast marine pilots in a survey completed by the States/British Columbia Oil Spill Task Force in 1996." (22)

The US Coast Guard has studied the topic of reducing the occurrence of oil spills through means other than structural changes to ships. (20) Their studies form the basis of proposed regulations which would apply to both US vessels and foreign-owned vessels in US waters. The Coast Guard's proposed regulations regarding "operational changes" target the same elements which have appeared here, as deficiencies in the conduct of some shipping companies. This includes training, maintenance, and proper work conditions. Specific points mentioned are such fundamental things as ensuring that crew get adequate rest, posting basic information and procedures in the bridge or control area, and stricter enforcement of maintenance.

As an aside, it should be mentioned that this short consideration of the subject has concentrated on changes like those mentioned above (which seem to have particular application to the Treasure spill), while ignoring other factors. All the maintenance in the world may not save a poorly designed ship, and there has been specific discussion about structural flaws in bulk carrier design, two of which may have played a role in Treasure's damage. One of these concerns faulty design of hatches, allowing them to be torn off by high winds so that the water from breaking waves can get into the uncovered holds. Another concerns the strength of interior structural elements in bulk carriers, in some cases not strong enough to withstand stresses such as the force of water when a neighboring compartment has been flooded.

There are also legal and financial issues affecting safety: for example that some protective institutions no longer fulfill their expected or historic roles. A thesis by a Cape Town attorney examines recent changes in how classification societies function: describing how they have largely moved from a strong emphasis on promoting maritime safety, to a narrower position furthering the short-term interests of owners and insurers. (25)

What is the practical significance of all this to individuals or groups who seek to protect wildlife? Increasing world commerce means increasing risks of oil pollution. Very large spills come from oil tankers, which are generally regulated and scrutinized more closely than other commercial vessels. In spite of this, "accidents" caused by human error (the likely cause of the Exxon Valdez spill (23)) continue to send millions of gallons of oil...
He also stated that enforcement of regulations to reduce the human errors and equipment failures that too often send a ship up against the rocks.

Ships that aren’t tankers, such as Treasure and Apollo Sea, get much less regulatory attention. Yet they carry enough fuel oil to cause a localized disaster. Like those involving tankers, these spills could be reduced to a considerable degree by better enforcement of existing regulations, and perhaps new laws or systems as well.

The world of maritime law is distant from the average individual. Many organizations, including some conservation organizations, are working on raising standards for ships involved in seaborne commerce and getting better enforcement of existing law. Concerned people can work with these organizations.

Perhaps individuals can accomplish the most by becoming familiar with the practices of the ports of their own city or country, and supporting the work they do. National maritime and port authorities can be urged by the public—individuals or interest groups—to inspect ships more often, more strictly, and use appropriate steps such as detention to get the attention of ship owners. Local commercial interests might be particularly eager to join in such efforts after a spill that interfered with harbor operations and affected tourism.

Oil spills and wrecks are a disaster for ports, even causing harbors to close completely. Thus all ports will benefit when any port makes stricter inspections, and requires that visiting ships comply with regulations. Authorities in Cape Town resisted saying that the harbor was closed by the spill, but there was a boom across the entrance for a time and ships had to be let in and out in groups.(9)

Ports may need bigger budgets if they are to carry out more inspections. But, as the Treasure spill has shown so well, crisis is very expensive, and may even cost more than prevention. Certainly it does when the non-monetary costs and damages are figured in.

Companies will resist changes that cost them money to implement; but failure to comply can be made expensive too. Every effort should be made to see that a company which causes environmental damage pays the monetary costs, and perhaps fines as well which could finance better enforcement. (Could a port require shipping companies with bad records to post a bond in order to enter?) Fines could also be used to pay for having expensive clean-up equipment on hand at the port, ready to use in a hurry. Almost 6 million gallons of oil poured out of Exxon Valdez in the first three and one-quarter hours after she ran aground; this is a little more than half of the total spill. (23)

Emphasis here has been on prevention, increasing the fitness of vessels and their crews to make future problems less likely. There is general agreement among shipping safety experts, such as the Coast Guard, about what changes would make a difference in that regard.

But once the ship has been wrecked or damaged, the situation is completely different: it changes by the minute, at the mercy of the weather and human error, and information reaching the authorities is fragmentary and uncertain. Unstoppable physical processes have begun: materials fail under excessive strain, flooding knocks out control systems. Treasure, for example, was badly damaged—perhaps already sinking—before she entered South African waters, and the weather delayed a thorough inspection.

According to a South African environmentalist quoted in the Cape Times on 2 July 2000, the South African government has the legal power to impound any vessel that constitutes a “serious risk to the environment”. (24) He also stated that this power, granted under the National Environmental Planning Act, has never been used.

Of course, drastic solutions are easier to embrace in hindsight. Such an impoundment would be an extremely serious business, likely to result in litigation by the ship’s owners and complaints from other shipping companies, perhaps threatening to use other ports when possible.

It may never be known whether impoundment of Treasure after the noon deadline expired could have changed the outcome. If the ship was already too low in the water to enter the Cape Town harbor when she arrived, and the seas outside the harbor were rough, it may not have been possible to get the oil off the ship, or get the ship well out to sea before she sank.

But—looking to the future rather than the past—when governments are considering such drastic measures, it is important that they have an idea how much support there will be among their constituents. They need to know that there is political and public support for taking appropriate action in defense of the nation and its environment.

The public response to the Treasure spill showed that people in South Africa and elsewhere put a high value on African penguins. Similar “statements” about wildlife have been made by the public after other oil spills in many places. It is vital to make this support more visible between crises, and to show that the values are shared by a wide cross-section of society including commercial interests.

This article has tried to demonstrate that events such as the Treasure oil spill are usually not isolated “accidents” occurring at random. More often, they are the result of human-controlled systems allowing ships and equipment to deteriorate, and failing to train and supervise officers and crew properly.

The sea is constantly testing ships and sailors; only by strengthening them just as persistently can we make oil spills into an endangered species.

References
C. Cheney: The Treasure oil spill: the results, the event, the background


Classification Societies are independent verification agencies which are hired by ship owners periodically to make an inspection verifying that a ship is sound and meets qualifications for her class. The inspectors are usually engineers or naval architects. Their inspections should cover everything from the steering gear and pollution prevention equipment to the soundness of the hull itself. Those who hire ships to carry their cargoes rely on classification society reports, and may hold the society legally responsible if loss occurs.


Web page prepared 9/97 by Stafford Reid, BC Ministry of Environment, Lands and Parks, Victoria, Canada. Task Force coordinator: Jean Cameron, States/BC Oil Spill Task Force Executive Coordinator, c/o Department of Environmental Quality, 811 S.W. 6th Avenue, Portland, Oregon, USA.

Abstracts from recent literature

(24) The wreck of the Exxon Valdez. Final Report. Alaska Oil Spill Commission. Published February 1990 by the State of Alaska. Accessed 5 October 2000. This portion available at <http://www.oilspill.state.ak.us/history/commish.htm> Various human errors occurred, including failure to follow company procedures such as always having two officers on the bridge, failure to follow traffic control “lanes” in the Sound, and negligence and errors of judgment brought about by fatigue, alcohol, or other factors.


C. Cheney: The Treasure oil spill: the results, the event, the background

These abstracts have been gathered from various electronic sources. We regret the variations in format.

TITLE: Marine ecosystem sensitivity to climate change.
AUTHOR: Smith, Raymond C.; et al.
E-mail: ray@icess.ucsb.edu
ABSTRACT: The authors summarize the data on climate variability and trends in the western Antarctic Peninsula region and discuss the data in the context of the long-term climate variability during the last 8000 years of the Holocene. Data on ecosystem change in the area is compared to data on climate variability. The results of the study show that rapid climate change in the 20th century has occurred along with a shift in the population size and distribution of penguin species.

INDEX TERMS: birds; climate; environmental factors; history; paleobiology; temperature | Adélie penguin; chinstrap penguin

TITLE: Synchronous underwater foraging behavior in penguins.
AUTHOR: Tremblay, Yann; Cherel, Yves*
e-mail:cherel@cebc.cnrs.fr
ABSTRACT: Researchers used electronic time-depth recorders to examine the synchronous foraging behavior of penguins. During a daily foraging trip in the chick guarding stage, two female northern rockhopper penguins dove in synchrony over seven consecutive hours during which they performed together 286 dives between three and 60 meters, and fed on the same prey. Most of the dives began and ended with a time interval of less than or equal to four seconds between birds. Differences in the duration and maximum depth of dives were slight.

TITLE: Novel tools to reduce seabird bycatch in coastal gillnet fisheries.
AUTHOR: Melvin, E.F., Parrish, J.K., and Conquest, L.L.
ABSTRACT: We examined several strategies to reduce seabird bycatch, primarily of Common Murres (Uria aalge) and Rhinoceros Auklets (Cerorhinca monocerata), in a coastal salmon drift gillnet fishery in Puget Sound, Washington, U.S.A. Our goal was to significantly reduce seabird bycatch without a concomitant reduction in target catch or an increase in the by-catch of any other species. We compared fish catch and seabird bycatch in nets modified to include visual alerts (highly visible netting in the upper net) or acoustic alerts (pingers) to traditional monofilament nets set throughout the normal fishing hours over a 5-week fishing season. Catch and bycatch varied significantly as a function of gear. Relative to monofilament controls, murres responded to both visual and acoustic alerts; auklets and sockeye salmon responded to deeper visual alerts only. Seabird abundance varied across multiple temporal scales: interannually, within fishing season, and over the day. At the international level, seabird entanglement was linked to regional abundance on the fishing grounds, a pattern that broke down at a local level. Within season, sockeye and murre abundance were negatively correlated, suggesting that if fishery openings were scheduled on peak abundance of the target species, seabird bycatch would be significantly reduced as a function of increased target fishing efficiency.

Finally both sockeye catch and auklet entanglement were highest at dawn, whereas murre entanglement was high at both dawn and dusk. Our results identify three complementary tools to reduce seabird bycatch in the Puget Sound drift gillnet fishery—gear modifications, abundance-based fishery openings, and time-of-day restrictions—for a possible reduction in seabird bycatch of up to 70-75% without a significant reduction in target get fishing efficiency. Although
The birds carried food from the sea in variations in the duration of foraging. Stomach contents were most often not delayed, the stored food enabled the males to feed the newly hatched chick, which then increased the success of nursery breeding. We suggest that this adaptation evolved in response to the availability of marine resources. [from Seabird Group Conference, 2000]

As with most birds, king penguin Aptenodytes patagonicus mates relieve each other in the task of incubation. The incubating adult then fasts for several weeks while its partner feeds at sea on myctophid fishes as far as 400 km or more from their breeding colony. Accordingly, foraging trips are particularly long and have variable duration. During the incubation period of 1996, at Possession Island (46° 25' S, 51° 45' E), Crozet Archipelago, we measured adult stomach contents upon their arrival from the sea and departure from the colony. The birds carried food from the sea in their stomach only when hatching might occur during their incubation shift. Despite their undergoing a long-term fast, the males conserved food in their stomach for as long as three weeks. During the incubation period of 1996, at Possession Island, we measured adult stomach contents upon their arrival from the sea and departure from the colony. The birds carried food from the sea in their stomach only when hatching might occur during their incubation shift. Despite their undergoing a long-term fast, the males conserved food in their stomach for as long as three weeks before hatching was to occur. The stomach contents were most often not used because the female returned before hatching. However, when she was delayed, the stored food enabled the males to feed the newly hatched chick, which then increased the chances of successful breeding. We suggest that this adaptation evolved in response to the variations in the duration of foraging trips resulting from irregular and unpredictable fluctuations in the location and availability of marine resources. [from Seabird Group Conference, 2000]

The myoglobin of emperor penguin (Aptenodytes forsteri) amino acid sequence and functional adaptation to extreme conditions.

AUTHOR: Tamburrini, Maurizio; Romano, Mario; Giardina, Bruno; di Prisco, Guido* 
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ABSTRACT: The author studied the structure-function relationship in emperor penguin myoglobin to see if it correlates with the species' lifestyle. The revised amino acid sequence contains one additional residue and 15 differences. Oxygen-binding parameters are well adapted to the diving behavior of the species and to the environmental conditions in which it lives. In the emperor penguin metabolic acidosis does not impair myoglobin function under conditions of prolonged physical effort.

The occurrence and purpose of huddling by emperor penguins during foraging trips.

AUTHOR: Kirkwood, Roger; Robertson, Graham 
AUTH. ADDRESS: Phillip Island Nat. Park, PO Box 97, Cowes, VIC 3922, Australia 

ABSTRACT: The authors present evidence of huddling by emperor penguins on foraging trips away from their colonies. They mounted temperature/light recorders on the backs of emperor penguins. The recorders showed light intensities consistent with night-time, but temperatures exceeded 23°C when ambient air temperatures were <15°C. The most likely explanation for low light and high temperatures is that the penguins huddled at night during journeys to and from the ice-edge, especially on arrival at the ice-edge, and occasionally between foraging days at sea.

SEXING LITTLE PENGUINS Eudyptula minor from Cook Strait, New Zealand using discriminant function analysis.

AUTHOR: Renner, Martin; Davis, Lloyd S. 
AUTH. ADDRESS: Dep. Zool., Univ. Otago, PO Box 56, Dunedin, New Zealand 

ABSTRACT: The authors derive a discriminate function for sexing adult little penguins based on morphometrics from the Cook Strait subspecies. They also investigated the possibility of sexual dimorphism in little penguin chicks. The authors computed a discriminate function analysis (DFA) with the following results: 92 percent of all birds were sexed with 95 percent certainty, 86.6 percent were sexed with 99 percent certainty. Differences in bill shape, while obvious in many birds, were often difficult to judge in the field, making DFA a more reliable technique.