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SECOND INTERNATIONAL CONFERENCE ON PENGUINS

Cowes, Phillip Island, Australia, 24–28 August, 1992

ABSTRACTS

Compiled by

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Following the success of the First International Penguin Conference in Dunedin, New Zealand in 1988, the Second International Penguin Conference was held in Cowes on Phillip Island in Victoria from the 24th to 28th August, 1992. Just over 100 delegates from Australia and overseas attended the conference which was hosted by the Phillip Island Penguin Reserve Committee of Management. Fifty-seven papers, including seven posters, were presented on a wide variety of contemporary topics in penguin biology and the abstracts of these are presented below.

We would like to take this opportunity to thank the other members of the organizing committee, Mike Cullen, Ian Norman and Pauline Reilly, for their assistance before and during the conference. We are especially grateful to the staff of the Penguin Reserve and, in particular, to Megan Edwards, Wendy Ritchie, Trudy Wellington and Felicity Officer for providing secretarial and banking services and to Wendy D'Amore, Mark Collins and Margaret Healy for help of various kinds. The conference was supported financially by the Phillip Island Penguin Reserve and Penguin Fund Japan, and stationery was supplied by the Commonwealth Bank. Finally we would like to thank all the participants for their enthusiastic contributions.

Sexual dimorphism in penguins

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The degree of sexual dimorphism varies within each of six genera. Those species which inhabit the colder waters and breed in more southern latitudes are less dimorphic in general than those breeding further north. This paper examines quantitatively the degree of sexual dimorphism based predominantly on bill dimension, for each species for which data exist, discusses its role in foraging ecology and breeding behaviour and examines the hypothesis that species breeding and feeding in the coldest regions are least sexually dimorphic as an adaption to energy conservation. The implication of variation in sexual dimorphism is discussed also in relation to the ability to sex penguins by discriminant analysis using morphometric parameters.

Factors affecting rookery size and dispersion among Pygoscelid penguins in Antarctica

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We tested the hypothesis, proposed for seabird populations in the tropical and temperate regions, that food supply during the chick-provisioning stage of reproduction affects the number of penguins foraging within range of each rookery and ultimately regulates the size of breeding populations in Antarctica. Our study area comprised two stretches of coastline where penguins have been most intensively and recently censused: Victoria Land and the western side of the Antarctic Peninsula, including the southern South Shetland Islands. Among Adelie *Pygoscelis adeliae,* Chinstrap *P. antarctica,* and Gentoo Penguins *P. papua,* rookeries were found to be highly clustered, with each cluster centred around one or two large rookeries. We found no significant negative correlation, as predicted by the hypothesis,

between rookery size and number of breeding pairs within parental foraging range of respective rookeries. Neither did we find a negative relationship of rookery size and size/distance to nearest neighbouring rookery. For Chinstrap Penguins, a significant positive correlation existed between rookery size and the number of rookeries/total population within the foraging range (50 km), but the correlations became more negative at greater distances. For the other two species, a significant negative correlation did exist but only at 150 and 200 km, well beyond the foraging range of parents. We suggest that if prey depletion occurs, it is over-ridden by aggregating factors, such as philopatry, social facilitation or predator avoidance, which are apparently more important in determining the location and size of the rookery into which penguins recruit. We further propose that, during the prebreeding period, interactions within the metapopulation (all breeders and non-breeders associated with the rookery cluster), in which individuals forage within a radius including but greater than that of parents, may help to explain the patterns observed.

Hydrodynamics of penguins: an experimental approach

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Penguins are the best adapted, wing-propelled divers among birds. They are important end-members of food chains of the Antarctic ecosystem, and considerable effort has been recently made to study the energetics of their underwater locomotion. Metabolic and field studies using more and more sophisticated telemetry and storaging devices are conducted, but still little is known on the basic hydrodynamic adaptions of the penguin body and the efficiency of the wings. The aim was to study and to compare three penguin species (Chinstrap — *Pygoscelis antarctica*, Adelie — *P. adeliae* and Gentoo — *P. papua*) with respect to their geometry and hydrodynamic performance. The thickness ratio of their bodies is high, ranging between 0.22 (Chinstrap) and 0.25 (Gentoo), and the length from head to broadest part of the trunk lies between 44 (Chinstrap, Gentoo) and 47 (Adelie) per cent of body length. Drag measurements with plastic models of original size in a circulation water tunnel resulted in very low frontal drag coefficients ($CD < 0.04$), pointing to an especially economical use of energy while swimming submerged. Flow visualization in a smoke wind tunnel (low Reynolds numbers) showed a smooth flow around the body, with separation occurring only in the tail region. In the same experiment, external devices were tested in order to minimize disturbances of these flow characteristics by varying the shape and the point of attachment. Measurements of the boundary layer provide some idea for the positioning and construction of speed sensors. The wings of the three species have a similar chord-length distribution. A small increase of aspect ratio in the sequence Adelie — Chinstrap — Gentoo is recognizable. The wing profiles are thick (thickness ratio ranging between 14 and 17 per cent of the chord length) and of low camber. Best performance is to be expected in the case of small positive angles of attack. But also with greater negative angles of attack a favourable lift to drag ratio (in the case of negative lift force) is likely to occur since the wing sections coincide with such profiles of the Gottingen series which show this phenomenon. Profile characteristics correspond with the course of wing motion during the stroke phase. The water meets the wing alternatively from the bottom and the top side during downstroke and upstroke respectively. The demands to the balance of forces and momenta are discussed with respect of the non-steady flow around the wing in the swimming penguin. Applying the unsteady lifting line theory of Philips *et al.* (1981) a thrust power efficiency (n_1) of 0.4 for the penguin's propeller can be estimated. A model of the most likely system of vortices created by the wings will be demonstrated.

Asynchronous hatching, size asymmetry, and chick survival in the Magellanic Penguin *Spheniscus magellanicus*

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Degree of hatching asynchrony, acting through establishment of size asymmetries among chicks is thought to be an important mechanism of brood reduction. Data from six breeding seasons of Magellanic penguins do not support this view. The hatching interval for first and second chicks varied from 0 to over 3 days, and first chicks were

significantly more likely to fledge than second chicks. However, except in cases of extreme asynchrony (> 3 days), the degree of asynchrony was a poor predictor of size asymmetries, and was not a significant determinant of first and second chick survival patterns. In only one of six years, the year of lowest reproductive success, was increased asynchrony well correlated with increased fledging success of first chicks and decreased fledging success of second chicks. Size asymmetries between first and second chicks determined brood reduction. The timing of initial food delivery appeared to be more important than hatching asynchrony in determining these size asymmetries and resulting mortality patterns.

An overview of haemoparasites in Jackass Penguins *Spheniscus demersus*

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During the past two years over 1 000 Jackass Penguins have had blood smears examined for abnormalities. Three haemoparasites have been identified, of which the first two are opportunistic: namely malaria and leucocytozoonosis. Malaria has been well described in the American literature, but leucocytozoon has only previously been described in the Fiordland Crested Penguin *Eudyptes pachyrhynchus*. Both diseases have a high mortality, and some clinical features and treatment will be discussed. The third disease, babesiosis, is endemic in the Jackass Penguin and seems to be of no clinical importance unless the bird is stressed (e.g. by oiling or injury). *Babesia* is transmitted by ticks, probably the Ixodidae, and is familiar in dogs as 'biliary fever'. It has never previously been reported in the penguin family. Combinations of these diseases may pose a serious threat to mainland colonies which have been established under human protection.

Feeding behaviour of Little Penguins *Eudyptula minor* in captivity

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The feeding behaviour of Little Penguins was examined in a 6 × 3.6 × 1.2 metre swimming pool. Live fish, mainly Yellow-eyed Mullet, were placed in the pool, and the subsequent chase sequences by the penguins were filmed. The effect of fish size on chase duration, handling time, swallowing time and various 'success' parameters was analysed. Manoeuvreability of the penguins during search and chase phases was quantified.

How many Little Penguins are there?

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The Little Penguin is an interesting animal, not only because it is worth so much to the Victorian economy, but because of its habits. Many of the current methods of estimating population size are not appropriate since: (a) The birds live underground and cannot be easily seen; (b) The penguins are never all ashore at the same time doing the same thing; (c) There are large seasonal changes in the numbers ashore at any one time. This affects the major assumption of most of the models, that of closure; (d) Some of the burrows in which the birds live are inaccessible. This talk looks at a 'tailor-made' approach to estimating the number of Little Penguins at the Phillip Island Penguin Reserve, Australia.

Reproductive effort in Adelie Penguins *Pygoscelis adeliae* at Palmer Station, Antarctica

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We calculated the energetics of reproduction of Adelie Penguins using time budgeting, doubly-labelled water (DLW) and time-depth recorders (TDRs). Reproductive effort (RE) was estimated as the foraging costs to replace materials invested in gametes and mass lost during the reproductive season, plus the cost of the additional foraging needed to obtain food for chicks. We calculated foraging costs and efficiency by regressing TDR data on foraging time against DLW data on metabolic expenditures and the energy equivalence of food delivered to chicks. Cumulative annual reproductive effort in Adelies near Palmer was approximately 41 megajoules (mJ), or about 3.5 per cent of the annual energy budget. Approximately 35 per cent of RE was replacement costs for mass losses, 28 per cent of RE was

used to feed small, guarded chicks and 37 per cent was used to feed large, creched chicks. Maintenance costs were about 3.25 mJ/day, or about 2.65 times basal metabolism. Increases in daily energy expenditures to support reproduction were relatively small: 15–35 per cent during the period of chick feeding and presumably less during the period of mass gain prior to the breeding season. Eggs comprised about 5 per cent of the RE of females; cumulative RE was roughly similar in males and females.

Foraging ranges of Adelie Penguins as determined by satellite tracking

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The foraging ranges of Adelie Penguins breeding at Bechervaise Island near Mawson were determined by satellite tracking using the Argos system. Six female and four male penguins were tracked over a total of 21 foraging trips spread throughout the breeding season. Long foraging trips of both sexes during the incubation period as well as short trips during chick brooding and guarding were covered by the tracking study. During the incubation period the off-duty birds travelled in a north-westerly direction; the females reached distances of 341 and 243 km from the colony and the males up to 164 km. Ice edge data gathered concurrently indicated that after walking to the closest point on the ice edge the birds moved slowly north-westwards in the pack, appearing to drift with the ice much of the time. Their return journeys were faster with average swimming speeds of 2.2–3.4 km/hr being maintained for periods of up to 24 hours. While gathering food for their chicks birds travelled in directions of up to 30° either side of north, making journeys of 3 to 5 days to the ice edge (up to 80 km away) and to the vicinity of the continental shelf (110 km distant). On their return journeys to the colony the birds swam at average rates (over periods of 12–36 hours) of 3.2–4.6 km/hr. Some birds left the colony for shorter periods (less than 2 days) but only travelled to a maximum distance of 12 km on these occasions. A major overlap occurs between Adelie foraging grounds and the locations of previous krill fisheries between 56° and 64°E and south of 65.5° latitude.

Seasonal foraging movements of the Little Penguin as determined by radio-tracking

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The foraging movements of Little Penguins *Eudyptula minor* from Phillip Island in Victoria were determined by radio-tracking. Adults (56) were tracked over five sessions during both breeding and non-breeding periods to elucidate seasonal differences, and to determine the utilization of Western Port as a feeding area. Although the majority of birds were located in the same general area during each session, foraging location varied widely with season. While short daily trips close to Phillip Island and into Western Port were common in February and April, longer trips lasting up to three weeks and covering over 200 kms were typical for September and December 1991, and July 1992. Foraging movements were examined in relation to other annual cycle events.

Annual breeding in the King Penguin

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The breeding cycle of the King Penguin *Aptenodytes patagonicus* was studied over a four year period at Archway Bay, subantarctic Marion Island by recording the breeding and moulting status of a large number of flipper-banded adult birds at regular intervals. King Penguins are unique among penguins in that a single breeding and moulting cycle lasts for more than one year, making successful annual breeding seemingly impossible without commencing breeding later each year. Very few birds that lay late in the season after breeding successfully in the previous season are successful the second time. However, we have found that most birds attempt to breed annually even though after a successful breeding attempt birds are almost inevitably forced into a subsequent late attempt with its associated low likelihood of success. Evidence suggests, however,

that some factors may operate to allow second consecutive attempts to start earlier than would be predicted by the summation of mean durations of obligatory activities. These findings are discussed in the light of aspects of the breeding biology of the species; including chick growth rates, adult moult, and the possibility that the lack of a fixed nest site and the lack of synchrony in breeding may facilitate low mate fidelity.

Recolonization of Robben Island by African Penguins *Spheniscus demersus*

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African Penguins *Spheniscus demersus* recolonized Robben Island near Cape Town in 1983, after an absence of at least 180 years. It is the first former breeding locality to be recolonized by African Penguins. In the 1980's, two new mainland colonies were also formed near Cape Town. At the time of establishment, all three localities were characterised by the regular presence of other seabirds or marine mammals, and by availability of shaded areas for nesting. Additionally, nearly 3000 rehabilitated African Penguins were released at Robben Island over a period of 13 years preceding recolonization. Most African Penguins at Robben Island select shaded areas for breeding. Limited recoveries of banded individuals suggest that Robben Island was recolonized by birds from the Cape Town vicinity. The numbers of African Penguins breeding at Robben Island increased from nine pairs in 1983 to almost 1900 pairs in 1991. The area of breeding was only a few square metres in 1983, but about 30 ha in 1991. The number of breeding pairs increased consistently, except in 1989 when there was a slight reduction. In 1989, there was also a low number of chicks fledged per nest, and poor subsequent recruitment to the immature population moulting at the Island. This can be attributed to a greatly reduced abundance of Cape Anchovy *Engraulis capensis* in 1989, combined with a scarcity of other prey items. Anchovy contributed 80–95 per cent of the diet of African Penguins at Robben Island during 1989–1991.

Interannual variation in population size and reproductive performance in Gentoo and Macaroni Penguins at South Georgia

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Breeding populations at selected colonies and hatching and/or fledging success of Gentoo and Macaroni Penguins have been recorded annually since 1976–77. There are many inter-species differences in the pattern of population change and breeding success which seem to reflect the very different ecologies (inshore and resident versus offshore and migrant) and demographics (first breeding at age 2–3 years versus 6–7 years in Gentoo and Macaroni, respectively). Comparisons are made with similar data for Adelie and Chinstrap Penguins at the South Orkney Island over the same period.

Energy expenditure of Adelie Penguins

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The energy requirements of Adelie Penguins were studied during three field seasons in Antarctica using respirometry and doubly-labelled water as well as implantable heartrate/body temperature transmitters. Energetics of birds ranging from 160 g (chicks) to 4900 g (adults) were studied with respect to time of breeding season, weather conditions, activity and locomotion. Walking was simulated using a treadmill and swimming was studied using a 21 metre water canal and sea water (4°C). Data on energy requirements are discussed with respect to activity budgets and locomotion models of the penguins as determined by other scientists via direct kinematic observation, or with the aid of recording devices attached to the birds.

Some aspects of the diving behaviour of Adelie Penguins *Pygoscelis adeliae*

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The diving behaviour of Adelie Penguins breeding at Magnetic Island, Antarctica, was examined on the basis of time-depth recorders

with 2-sec. sampling interval, which also store information on swimming speed. Deeper dives showed a larger variance in swimming speeds, and this was due to bouts of steady swimming at depth being interrupted by sudden slowing down events which are inferred to be related to foraging (either sighting or capture of prey). This is consistent with the depth and time of day of such events in relation to putative prey. Other parameters of Adelie dives will be examined and contrasted with a sample of information on Emperor Penguins *Aptenodytes forsteri*.

A haematological survey of wild Little Penguins

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Taronga Zoo and the Sydney Water Board have embarked upon a three-year study of wild and rehabilitated Little Penguins. Part of the project involves the monitoring of their health which involves the collection of blood samples for haematology, biochemistry and heavy metal analysis. Taronga's clinical laboratory has undertaken the haematology and also a microbiological survey of their faeces. We have examined approximately 300 blood samples over a two-year period, involving four field trips per year to both Lion and Bowen Islands. This paper will present the methodology, difficulties encountered and abnormal findings including the discovery of an unusual red cell parasite in less than one per cent of the population. Because of the large volume of data collected at four periods during each year, we have been able to establish normal haematological ranges for the birds from both islands.

Rehabilitation of Little Penguins *Eudyptula minor* on Phillip Island

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Up to 169 Little Penguins have been treated for injury or illness at the Phillip Island Penguin Reserve each year since 1984. Over the past three years, the number of penguins requiring rehabilitation has increased dramatically. New facilities have been designed to cater for this demand and to enhance the success of rehabilitation. Between July 1989 and June 1992 the most common causes of illness were oil spills (40.9%) and starvation (39.1%). Starvation appears to be the major cause of birds being beach-washed with higher numbers being treated between January and April. Primarily these consist of first-year birds having difficulty finding food after fledging and also pre- and post-moult adults. The percentage of penguins released varies between years. Although not significant, the years of lowest percentage released correspond with the years when the greatest number of chicks are treated. The true success of rehabilitation can be measured by the numbers of rehabilitated penguins seen again in the wild. Thirty-one per cent of rehabilitated penguins that were known to have come from the Penguin Parade were seen again. This compares favourably with 33 per cent of other penguins banded in the Parade being seen again. These results suggest that the survival of Little Penguins rehabilitated at the Penguin Reserve is similar to that of other penguins within the colony.

The cost of reproduction in Little Penguins *Eudyptula minor*

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Survival in birds is generally considered inversely related to reproductive effort. The cost of reproduction in terms of future reproductive output in Little Penguins was examined by recording parental weights, breeding productivity and subsequent parental survival at four breeding sites on Phillip Island between 1984–91. Parental weight loss during the breeding season varied with sex and productivity but not in the predicted way. Females lost significantly more weight than males. Unsuccessful parents and those raising only one chick also lost weight but males successfully rearing two chicks did not lose weight. Survival was greater for birds which were heavier in September and October (also November-males; June-females), coinciding with egg-laying and

incubation in most years but was not related to weight at the end of the breeding season (January-February). Similarly, parental survival to the end of the next moult, start of next breeding season and end of next breeding season appeared independent of breeding productivity.

The control of behaviour

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The behaviour of penguins has been well documented, but what controls the expression of behaviour remains little understood. And yet, the timing of behaviours has profound effects on the reproductive success of penguins. To address this, a colony of Adelie Penguins was kept under continuous observation for more than 1 500 hours during a single season. The behaviour of each penguin present in the colony was sampled every 15 minutes using instantaneous scan sampling. In addition, all occurrences sampling was used for arrivals and departures, copulations, ecstatic displays and chick feeding. The effects of time of day, time of season, activity of conspecifics and the weather on behaviour are examined, drawing attention to the importance of endogenous rhythms, social facilitation and thermoregulation as regulators of behaviour. This is discussed in light of recent evidence for hormonal control of behaviour and the implication for the breeding success of penguins.

Thermoregulation at sea: does it influence the energetic cost of locomotion?

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Subantarctic penguins spend much of their lives at sea in water that ranges from freezing to 5°C. The average metabolic rate of Gentoo Penguins *Pygoscelis papua* and Macaroni Penguins *Eudyptes chrysolophus* ranges from 16–22 $W \cdot kg^{-1}$ during foraging sojourns at sea. This range is approximately seven times the estimated standard metabolic rate of these birds. It is unlikely that the high metabolic rate of the foraging penguin is due solely to the energetic cost of swimming. In this study, we examine the relative cost of locomotion and thermoregulation for swimming penguins. A thermal model based on morphological measurements and the thermal insulation of the skin and feathers is developed for active and sedentary birds. Primary avenues of heat loss are determined for the chest, back, wings, and feet. The contribution of each of these areas of heat loss to the thermal balance of penguins in water will be discussed.

Partnerships in penguin conservation

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Without active intervention, it is possible that one of the penguin species could become extinct within our lifetime. As populations diminish in their natural habitat, wildlife and zoo managers realize that we must adopt management strategies that will reduce the risk of species extinction. The Captive Breeding Specialist Group (CBSG), in collaboration with experts in SSC and ICBP Specialist Groups, wildlife agencies, the global captive breeding community, non-governmental organizations, and the private sector, is evolving a series of programmes, activities, and partnerships to respond to this challenge. Two of these programmes are: (1) Conservation Assessment and Management Plans (CAMPs) which allow evaluation of all species and subspecies in a broad group to set global priorities for conservation action and information-gathering; and (2) Population and Habitat Viability Analyses (PHVAs) which combine analytic and simulation techniques to look at the effects of an array of variables on the survivability of populations with the ultimate goal of preventing extinction and providing for recovery in the wild. The CBSG was invited by the New Zealand Department of Conservation and Orana Park Wild Life Trust to conduct a Global Penguin CAMP and PHVAs for the New Zealand penguin species, to be held at a workshop in August 1992. This paper outlines the findings of the workshop.

Management of Little Penguin nesting habitat

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A study of the breeding biology and habitat requirements of the Little Penguin *Eudyptula minor*, was undertaken on Bowen Island, Jervis Bay. The study was distinctive because the vegetation of Bowen Island is complex compared to other Australian localities where penguins breed, and this provided a unique opportunity to compare breeding success in different vegetation assemblages, particularly woodland and tussock scrubland. Only 65 per cent of burrows examined in tussock scrubland were used for nesting, compared to 94 per cent in woodland. In tussock scrubland, penguins produced 1.03 chicks per pair, 50 per cent of pairs produced maximum broods of two eggs, and 71 per cent of eggs laid hatched. Only 5 per cent of pairs then went on to lay second broods in the same season. In contrast, those penguins nesting in woodland produced 1.57 chicks per pair, 90 per cent of pairs produced maximum broods, and 95 per cent of eggs laid hatched. Over 20 per cent of pairs went on to lay second broods within the same season. Mean date for onset of laying was two weeks earlier in woodland compared to tussock scrubland. The significance of such marked differences are discussed.

Nutritional balance studies with Little Penguins *Eudyptula minor*

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Little Penguins were housed indoors at ambient temperature with day:night length adjusted to the natural times. The birds were hand fed twice a day with either whole pilchards or mackerel or with a mixture of pilchards and squid. Since hand feeding made feed intake independent of voluntary appetite, the amount of food given could be kept constant over the experimental period. It was therefore possible for birds to be kept in metabolism cages for only 24 hours (instead of the conventional 3 to 5 days) for the collection of excreta. Two to three 24-hour collections were made for each bird. Feed and excreta were dried and analysed for crude protein, crude fat, ash and energy and digestibilities of the different foods was calculated.

Automatic weighing of electronically-identified King Penguins

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Weighing breeding penguins each time they enter their colony reflects accumulation of body reserves and/or food in stomach during foraging at sea. Weighing them at the times they leave their colony indicates how much reserves have been depleted and/or food has been delivered to the chick. A major problem until now, however, was that human presence in a penguin colony and handling the birds have a serious effect on their breeding performance. This problem was solved in January 1991, by using an automatic weighing and identification system. There is a single way in or out to a part of a colony of King Penguins in Crozet. The installation is such that the 200 pairs breeding there have to pass over a weighbridge. The identification system (TIRIS) was developed by Texas Instruments to identify individual farm animals. We used it for the first time in wild animals. Infra-red cells indicate the direction of passage. All data are sent to the scientific station by a high frequency communication link. The system has been in continual use for more than one year. Our data are discussed in terms of the gain in body mass of the birds during their foraging trip as an indicator of sea-resources.

Is wearing a tuxedo a health risk? Contaminant levels in Little Penguins

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The concentrations of heavy metals and organochlorine compounds in tissues of the Little Penguin *Eudyptula minor* were determined for both wild and captive populations. Penguin samples were collected from Lion Island, beaches around Sydney, Bowen Island, Phillip Island and the Taronga Zoo collection. Egg contents, liver, fat and brain tissues were analysed for the non-essential heavy metals Cd, Hg, Pb and the essential

heavy metals Ni, Cr, Cu, Zn, As, Se. Lead was not present in any samples. Copper and mercury were the only metals found at concentrations above literature values for high latitude penguins. The highest concentration of most metals was found in the liver tissue. The lowest concentrations of Cd, Cu, Zn, Se were recorded in captive birds. The tissue samples were also analysed for the pesticides DDT and its analogues, the cyclodienes (dieldrin, aldrin, lindane) and chlordane and its metabolites as well as the organochlorine compounds HCB and PCB. DDE and PCB were found in all penguin tissues at all geographic sites in moderate concentrations. Some penguins near Sydney contained DDT and chlordane (rather than their metabolites) in low concentrations indicating recent exposure to pesticides. Egg contents generally contained fewer organochlorines at lower concentration than other tissues. The implications of the data in assisting an assessment of the health of Little Penguin populations will be discussed.

Measuring the impacts of human visitation to Adelie Penguins breeding in Antarctica

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There are many elements of human activity currently or potentially impacting upon Antarctic wildlife. Human presence in the region is increasing as commercial tourism, scientific activity and the infrastructure to support these activities expand. Visits to Adelie Penguin *Pygoscelis adeliae* colonies are popular amongst people travelling to Antarctica although uncontrolled human activity can alter penguin behaviour, physiology, breeding success and overall population stability. Research is planned for the Davis region (Australian Antarctic Territory) to commence in the 1992/3 summer which applies a controlled experimental approach to studying the impact of disturbance to breeding Adelie Penguins. Various colonies will be subjected to four human approach treatments which are designed to determine — (1) minimum safe approach distances to colonies; (2) optimal speeds of observer approach; (3) the influence of prolonged approach style, and (4) the effect of different observer group sizes on bird response. A number of control colonies, which are not disturbed by human approach experiments, will also be monitored and the nature of habituation to disturbance will be experimentally tested. Behaviour and heart rate will be used to indicate disturbance, however, breeding success and long-term population stability will also be measured as this research will continue in future years. Results should be useful to the development of codes of conduct and management guidelines which offer effective control over human behaviour around this, and other seabird groups in Antarctica.

Downy feathers of Emperor Penguins *Aptenodytes forsteri* and other diving birds: an analysis of microstructure and function

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Although downy microstructure has been useful in avian identification, few studies have examined barbule morphology of related species and ecologically similar non-relatives. Similarities in microstructure among such bird groups could provide an explanation linking form and function in down feathers. Using the scanning electron and light microscopes, barbule morphology was characterized for a total of seven diving and non-diving species. Similarity in structure existed among the barbules of all divers, whereas related diving and non-diving species diverged in morphology. Downy barbules of aquatic birds which contain distally located nodal prongs and a smooth, node-free proximal region may share a common function. Interactions between barbules with this structure could more effectively trap an insulative layer of air against a waterbird's body.

Ecological overlap in four sympatrically breeding penguin species at Macquarie Island

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The diet and breeding biology of four species of penguins *Aptenodytes patagonicus, Pygoscelis papua, Eudyptes schlegeli* and *E. chrysocome* are compared. There was least dietary overlap between *A. patagonicus*, which feeds almost exclusively on pelagic myctophid fish, and the two *Eudyptes* species, in which euphausid crustaceans are an important component of the diet. *P. papua*

also had a predominantly fish diet, but a significant component of this was inshore species. The greatest degree of dietary overlap was between *E. schlegeli* and *E. chrysocome*. A comparison of the reproductive strategies of the four species highlights the ecological similarity of the *Eudyptes* species. The breeding cycles of these species are quite similar, except for a three to four week temporal shift in the onset of laying, with the total breeding cycle taking less than five months. *A. patagonicus* has a totally different strategy. Breeding pairs feed their chicks for 11 months, producing a 14 month breeding cycle, with the end result that pairs of birds must miss every third or fourth breeding season. The total amount of each prey species brought ashore to feed chicks during a breeding season is also compared between the species. The implication that this has for potential inter-specific competition is discussed in the light of recent demographic changes in some of the species.

Penguin Conference Japan and the first survey of penguins on display in Japan

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POSTER — PCJ is an organization for exchanging information about penguins and for promoting the activities of conservation, management and research on penguins. In 1990, through the efforts of many keepers and researchers working in zoos, aquaria and public institutes, the First National Conference was held in Tokyo at Ueno Zoo. All those attending the conference found that the penguin exhibitions in Japan have faced the same difficulties that Simon Blackwell had pointed out in the introduction of "Penguin Management" (Proceedings of a Symposium in 1989). He noted that our knowledge of penguins is limited, but we have the opportunity to change this situation now. He emphasized that we can do something worthwhile for the birds, e.g. education, manage captive populations to eradicate the need for birds to be taken from the wild, and raise money for research in the wild and in captivity. Japanese establishments have other serious problems that have already been resolved in other countries. In particular, there is no comprehensive studbook in Japan even though nearly 90 zoos and aquaria have their own collections. In March 1991, PCJ sent a questionnaire to 61 exhibitions and 56 replies were received. This was the first comprehensive survey of penguins in captivity in Japan. The total number of Humboldt Penguins *Spheniscus humboldti* in the 45 collections responding was 573. A second survey later in 1991 recorded an additional 200 individuals and took the total to 773.

Osmoregulation and energetics of Adelie Penguin chicks

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Adelie Penguins living near Palmer Station, Antarctica eat almost exclusively marine invertebrates, primarily krill *Euphausia superba*. Ion concentrations in the extracellular fluids of most marine invertebrates approach those in seawater. Adult Adelies excrete excess ions (primarily sodium and chloride) via very efficient kidneys and the supraorbital salt glands. Adelie chicks receive the same food, regurgitated by the adults, but appear to have less powerful kidneys. Maximum urine osmolalities measured in adult Adelies in the field approach 1 000 mOsm, but in chicks under 500 g are always less than 800 mOsm. By contrast, maximum osmolalities of salt gland secretions approach 1700 mOsm in both adults and small chicks. These data suggest that small chicks rely relatively more on their salt glands for ion excretion, and gradually rely more on the kidneys as they grow into adulthood. Results of salt loading experiments show the opposite: small chicks excrete the majority of a salt load via the kidneys, and this proportion of salt excreted via the kidneys decreases as chicks develop.

Reproductive endocrinology of King Penguins

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In King Penguins, the season of reproduction is less synchronized than in most other penguin species. Laying can occur from November to the end of February. However, laying to fledging usually lasts 14–16 months. This means annual

breeding is impossible. Our study was conducted to provide correlational data on endocrine and behavioural events during seasonal breeding in King Penguins. Steroids and pituitary hormones were measured from serial blood samplings done on a colony at Possession Island (Crozet Archipelago). The onset of breeding activity is characterized by plasma LH levels increasing immediately after birds had moulted. They remain high during courtship and fall after copulation. Gonadotrophin secretions entrain sustained plasma testosterone levels in males and increased estradiol and progesterone levels peaking at ovulation in females. In both sexes, prolactin (PRL) levels begin to rise before ovulation, participating in the readiness to incubate. During each incubation shift PRL secretion increased. As in other altricial species, PRL is maintained at a high level after hatching, in relation to the chick rearing. Changes in plasma LH are inversely related to concentrations of plasma PRL. Further experiments are under way to test if temporal relationships between PRL and LH could be involved in the determining of breeding frequency.

First survey of Fiordland Crested Penguins: a review

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We review the success of a joint university and tourism venture to conduct the first complete survey of Fiordland Crested Penguins. To date, the central part of the species' range has been surveyed, from Milford Sound to southern Fiordland. Surveys are conducted during incubation when nests are easiest to locate. Results indicate a dramatic reduction in numbers during the 20th century. We estimate that currently there are less than 1 000 nests for the species per season.

A new low-profile transmitter package for Little Penguins *Eudyptula minor*

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POSTER — During behavioural studies of wild animals, it is important that the methodologies employed do not significantly influence the normal behaviour and well-being of the individuals under investigation. When foraging, the Little Penguin *Eudyptula minor* spends a large proportion of time swimming underwater and at moderate speeds. When considering the hydrodynamic resistance of water, coupled with the bird's small size and moderate swimming speed, the minimization of drag caused by any attached device becomes a major priority. In light of this, Faunatech was approached by the Phillip Island Penguin Reserve to develop a new low-profile and streamlined transmitter package for use on Little Penguins. To achieve the minimum possible shell thickness, a new technique employing pre-formed plastic shells was developed. The shells are vacuum formed from 0.5 mm ABS plastic to precise dimensions, then pressure glued around the transmitter electronics. To achieve maximum waterproofing, 30 mm of the antenna lead-in wire is sandwiched in the resultant glue flange. A separate antenna anchor box ensures that stresses applied to the whip antenna do not compromise the water sealing of the internal electronics. The frontal area of the new package is equivalent to 2.5 per cent of that of an adult Little Penguin, cf. 5 per cent of a previous design used by the Penguin Reserve.

Murder by penguin: Adelie Penguins *Pygoscelis adeliae* destroy eggs and kill chicks of the South Polar Skua *Catharacta maccormicki*

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POSTER — Since they were first described, South Polar Skuas have been characterized as rapacious seabirds that prey extensively on the penguins they nest near. From six seasons of observations at Cape Bird, Ross Island, Antarctica, it is apparent that penguins also have a substantial impact on the reproductive success of South Polar Skuas. On average, skuas lose half of their eggs before they hatch. Adelie Penguins are responsible for 20 per cent or more of the destroyed eggs. In addition, penguins occasionally attack and kill skua chicks. Interestingly, these are not predation events. Adelie Penguins never eat any of the skua egg or chick remains.

Diving patterns of foraging Adelie Penguins *Pygoscelis adeliae* near Ross Island, Antarctica

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As diving marine birds, Adelie Penguins *Pygoscelis adeliae* must balance the physiological demands of diving with time at the surface for recovery. In addition, during the breeding season, they are central place foragers. They must optimize time away from their nest with their ability to feed. Using Time-Depth Recorders I recorded the diving behaviour of Adelie Penguins during the incubation, guard, and creche stages of the breeding season. Here I report the characteristics of over 10000 individual dives. Most dives were less than 50 m deep, but the birds occasionally dived over 75 m (max. 105 m). In addition, the penguins spent more of their time diving (feeding) when they were feeding chicks.

Foraging range of Yellow-eyed Penguins *Megadyptes antipodes*: preliminary results of a radio-telemetry study

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Radio transmitters were attached to six Yellow-eyed Penguins *Megadyptes antipodes* during guard stage (1990–91) and 14 birds during incubation, guard and post-guard stages (1991–92) at Otago Peninsula, South Island, New Zealand. During incubation, birds took on average 3-day trips to sea but usually took 1-day trips at other times. The foraging ranges of some individuals were influenced by the stage of breeding, travelling shorter distances when they had chicks to feed. Others had individual patterns regardless of breeding status, ranging from regularly foraging inshore (<10 km) to foraging offshore (10–40 km). The main difference during the breeding cycle was in the guard stage, when few birds travelled more than 20 km. The mean distance of locations from the colony in all seasons was 17 km, ranging from <2 km offshore in water <30 m deep to spread out over the continental shelf, generally 5–40 km in water 50–70 m deep. This may be an area of favourable currents and benthic community.

Penguin responses to human disturbances in Antarctica: some issues and problems in determining disturbance by tourists and others

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Recommendation I–VIII of the first Antarctic Treaty Consultative Meeting (1961) recognized that the activities of people near penguin colonies have the potential to cause disturbance. Many authors acknowledge that there is a need to protect penguins from such disturbances, particularly in view of increasing tourism in the area. However, the categories of penguin response to human presence generally deemed to indicate disturbances are too limited to allow the generation of the specific information required to ensure this protection. This paper advocates an approach to human-induced disturbance of penguins, based on Nimon and Dalziel's (1992) concept of cross species interaction, which involves the specification of (a) what stimulus aspects of human presence affect penguins, (b) the changes in behaviour they evoke, and (c) the contextual variables which may influence the interaction. Other issues and questions are raised, such as the problem of defining significant disturbance. In view of the naivety of penguins in relation to people, it is especially important to develop non-invasive techniques of monitoring to minimize the observer-induced disturbance which may affect both tourist-monitoring studies, and research on natural penguin behaviour. This research forms part of a wider research project, concerned especially with the management of tourists and other visitors in Antarctica.

Variation in the summer diet of King Penguins *Aptenodytes patagonica* at South Georgia Island

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The diet of King Penguins at South Georgia was examined on nine sampling occasions, from November through to March, by analysis of

stomach contents. Fish and squid accounted for >99 per cent and <1 per cent of the wet mass respectively. The dominant species during the whole period was *Krefftichthys anderssoni*, which constituted 100 per cent of the fish prey in the first half of the period. In the second half *Electrona carlsbergi* constituted a small part of the prey. The variation of length and weight of the fish is given.

Long-term population trends and observer biases in Emperor Penguin population estimates

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Australian Antarctic Division expeditioners have censused Emperor Penguin numbers at colonies along the Mawson Coast of Antarctica for over 30 years. In order to gain a yardstick on the accuracy of past estimates 15 overwintering expeditioners from a range of employment vocations were asked to estimate penguin numbers at two colonies in mid-winter. The mean value of a 30s duration visual assessment of a small (3 000 attendant birds) colony with no attempt to systematically count approximated the actual number and was statistically indistinguishable from results of traditional census methods which included a systematic ground-based census and a census which afforded a three-dimensional perspective of huddling penguins. At a medium-sized colony (12 400 attendant birds) the quick assessment method underestimated actual numbers by 30 per cent on average. Results of systematic censuses from the ground and elevated vantage points were similar. While individual estimates varied greatly, an assessment of cumulative scores suggest three or four observers working independently might yield mean estimates within 10 per cent of actual numbers. In spite of this result more objective census methods are recommended. Results have implications for our understanding of Emperor Penguin population status. Numbers at two Mawson Coast colonies seem reasonably stable.

Breeding success of Little Penguins on Lion Island, New South Wales, Australia

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Lion Island is one of the Little Penguins' *Eudyptula minor* northerly breeding colonies on the Australian east coast. In the 1990/1991 season the success of 32 breeding pairs was 68 chicks fledged (2.13 chicks per pair) with 25 per cent of pairs having successful second clutches. In the 1991/1992 season the success of 26 breeding pairs was 40 chicks fledged (1.54 chicks per pair) with 15 per cent of the pairs having successful second clutches. One hundred and six chicks were banded as fledglings on Lion Island; none of these birds have been retrapped on the Island.

Daily routine, time and activity budgets of Humboldt Penguins *Spheniscus humboldti* at Punta San Juan de Marcona, Peru

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Data presented here are the results of a study undertaken at San Juan de Marcona, Peru, in February–April 1987 during the late moulting period (period 1) and the occupation/early breeding period (period 2). Data will be presented about the number of animals present at various areas of the study site. The location of the animals differed between period 1 and period 2. In period 2 continuous behaviour protocols (focus animal) were taken over 20 minute periods. The grouping of all observed behaviours into five behaviour groups will be discussed. The grouping of at least two behavioural displays differs from the generally accepted grouping found in the literature. Time and activity budgets (on the basis of the five behaviour groups) are being analysed on four factors: sex, presence of partner, time of day and distance to nest. A short comparison will be made of the behaviour of these penguins in the wild with their behaviour in captivity. Finally, how these results assist in understanding how animals cope in different circumstances will be discussed.

Observations of penguins at sea in the Southern Ocean during the 1991–92 austral summer

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Penguin distribution data, collected by forward quadrant counts, made during two voyages of the R.S.V. *Aurora Australis* are presented. Notable observations were groups of sub-adult Adelie Penguins *Pygoscelis adeliae* north of the pack ice in January-February, large concentrations of recently fledged Macaroni Penguins *Eudyptes chrysolophus* 600 nm south-west of Heard Island in early March, Rockhopper Penguins *E. chrysocome* 300 nm south of Macquarie Island in October and Royal Penguins *Eudyptes schlegeli* 160 nm north of Macquarie Island and 300 nm south in October.

Unfit mothers? Egg ejection by Royal Penguins

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POSTER — The six species of crested penguins (genus *Eudyptes*) exhibit a unique form of obligate brood reduction in which the first of two eggs laid is much smaller than the second and is seldom raised to fledging. Although very early loss of first-laid eggs is common in at least three species the cause of mortality is unclear. Through continuous daylight observations of Royal Penguins (*E. schlegeli*) during the laying interval, I witnessed the loss of 12 first-laid eggs. Eleven of these appeared to result from deliberate, infanticidal behaviour by the female parent (eggs were scraped from the nest with a hind foot or removed with the bill). In 61 per cent of 33 observed nests, first eggs were lost within the 24 h period *before* second eggs were laid. I assessed the viability of first vs. second eggs with swapping experiments. First eggs were removed at laying from 89 nests and used to replace second eggs in 46 of these. First-egg nests had a hatching success of only 48 per cent, significantly lower than that of an unmanipulated control group of 45 nests (69%) and only half that of second-egg nests (93%). I propose that low first-egg viability is a non-adaptive consequence of the extreme egg dimorphism in royal penguins (second eggs are 57% larger by volume than first eggs), that the reduced insurance value of these eggs would be further offset by even a small cost of incubation, and that ejection behaviour has evolved secondarily to minimize wasted investment in first-laid eggs.

Preliminary results of serum biochemistry analyses on the sera of Little Penguins *Eudyptula minor* from the New South Wales coast

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One hundred and fifty-five serum samples from Little Penguins from Lion Island (68) and Bowen Island (78) have been analysed to establish normal values for 16 variables and to test for differences in these variables between the two sites, and between Lion Island penguins and those brought to Taronga Zoo (9) for rehabilitation. Highly significant differences between Lion Island and Bowen Island samples were found in serum Na ($t = 3.40$, $p = 0.0009$), Cl ($t = 4.46$, $p < 0.0001$), triglycerides ($t = 4.23$, $p < 0.0001$) and Cu ($t = 4.51$, $p < 0.0001$). Significant differences were found in serum K ($t = 2.43$, $p = 0.016$), BUN ($t = 2.71$, $p = 0.0077$) and pseudocholinesterase ($t = 2.96$, $p = 0.0036$). No significant differences were found in serum P, Zn, Mg, protein, AP, LDH, AST, CK and creatinine. Significant differences were found between sick penguins and Lion Island penguins in Na, K, Zn and LDH. The significances of these findings are discussed.

The reliability of morphometrics in determining sex in Little Penguins *Eudyptula minor*

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POSTER — The reliability of beak characteristics (length, depth and width) of 'adult' Little Penguins in determining sex was investigated using 50 carcasses. There were significant differences between the sexes in beak length ($t = 4.07$,

$p = 0.0002$), beak depth ($t = 4.79$, $p < 0.0001$) and beak width ($t = 4.67$, $p < 0.0001$). Discriminant analyses showed the use of all three variables gave the most accurate prediction of sex with an accuracy of 82 per cent (81% for males and 83% for females). Use of the classification formula of Gales (1988) predicted the sex of the birds with an accuracy of 72 per cent (63% for males and 89% for females). The usefulness of morphological variables in determining sex is discussed.

Parent–offspring recognition in the Fiordland Crested Penguin *Eudyptes pachyrhynchus*

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Fiordland Crested Penguins were tested for their ability to recognize their offspring by vocalizations, using play-back techniques. Preliminary tests were conducted at three stages (5–9 days, 14–18 days and 22–28 days after the first egg hatched) on adults during the guard stage in the nesting season. Recordings made of chick calls were analysed using a sonograph. The calls were found to be individually distinctive at all three of the stages mentioned above. Proposed work on offspring recognition of parents is also discussed.

The effect of climatic fluctuations on Adelie Penguins

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Historically, changes in numbers of Antarctic Penguins have been attributed either to human disturbance, the reduction of baleen whales, or climate perturbations. Monitoring of Adelie Penguin rookeries on Ross Island shows that the overall breeding population increased during the 1970–1980s, but that there was considerable annual variation in numbers attempting to breed. Preliminary results from a study comparing breeding population size, breeding success, 'chick condition', and environmental factors are presented and discussed. It seems that Adelie Penguin population parameters are sensitive indicators of both annual and long-term climate change.

Intersite variation in Magellanic Penguin *Spheniscus magellanicus* diet in the Falkland Islands: implications for monitoring

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Magellanic Penguins *Spheniscus magellanicus* breed at over 90 locations in the Falkland Islands. Intensive studies of diets at three sites over four breeding seasons confirm that this species is an opportunistic inshore feeder. Prey taken include immature fish (principally nototheniids, Southern Blue Whiting *Micromesistius australis* and sprats *Sprattus fuegensis*), the decapod crustacean *Munida gregaria*, and small squid (predominantly *Gonatus antarcticus* with some *Loligo gahi*). Simultaneous investigation of diets at two colonies, 60 kilometres apart, highlighted the extreme variation between sites in the types of prey consumed. These results demonstrate the difficulties in drawing meaningful conclusions about feeding ecology and potential threats posed by fisheries from short-term studies at a limited number of breeding colonies.

Sharing our future with penguins: introduction to the Penguin Fund

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POSTER — The Penguin Fund was set up in 1986 to study the biology of penguins and to conserve penguins in their own environment. All the members of the secretariat and staff are volunteers. The main activities of the Penguin Fund are as follows:

1. Contribute to groups and individuals undertaking penguin protection plans.
2. Assist individual penguin researchers.
3. Send volunteers to wild penguin reserves.
4. Investigate wild penguins in their habitat.
5. Investigate current penguin research.
6. Collect material and literature on penguins.
7. Publishing books and pamphlets about penguins.

In the last six years, the Penguin Fund has offered contributions to: the First International Conference on Penguins (1988), the Second International Conference on Penguins (1992), the Yellow-eyed Penguin Trust (1988, 1990, 1991),

the Phillip Island Penguin Reserve (1987, 1988, 1989, 1990, 1991), the Charles Darwin Foundation (1987, 1988, 1989, 1990, 1991), the South African National Foundation for the Conservation of Coastal Birds (1987, 1991) and researchers (1988, 1989, 1990). In all, 2 150000 yen (A$22 113) have been provided. The Penguin Fund receives contributions from donors. Membership fees are not essential and funds are raised by a variety of means including auctions for penguin goods (for example stationery, accessories, statues and dolls) and so on. We have our own scientific programme. President Mr. Masahiro Aoyanagi delivers scientific lectures about penguin biology and ornithology.

Activity patterns during the breeding season of Gentoo Penguins *Pygoscelis papua* at Ardley Island, South Shetlands, Antarctic

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POSTER — Median duration of incubation shifts was about 24 hours. In the early incubation period we registered a striking peak of nest reliefs between 1800 and 2200 h. This pattern was less apparent later in the period and therefore closer to the solstice — a possible indication of light intensity dependence. The time that non-incubating birds spent away from the colony decreased with departure time. During the brooding period (guard stage) the birds returned from their foraging trips (median duration 8 h) in two waves, one in the morning and one in the evening.

Scrambling for a meal! Competition by selfish Jackass Penguin *Spheniscus demersus* siblings

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Several theoretical models explore avian begging/feeding relationships, but few studies have examined such relationships in the field. We recorded begging and feeding by Jackass Penguin chicks to (1) test two predictions of the 'scramble feeding' model (Parker, G. A., Mock, D. W. and Lamey, T. C. 1989. *Am. Nat.* **133**: 846–868), which takes into account competitive asymmetries that may develop when hatching is asynchronous, and (2) investigate the apparent advantage of asynchronous hatching (i.e. improved feeding efficiency). Feeding of Jackass Penguin chicks involves intense competition between two unequal-sized sibs, for a finite amount of food delivered once daily. Our data on number and duration of feeding bouts within a standardized feeding episode, and mean amount of food delivered per second, support the primary prediction that 1st-hatched sibs always spend less on begging than 2nd-hatched sibs. However, we do not find clear relationships between changes in the magnitude of competitive asymmetries and the differential begging costs between siblings. Predicted patterns of behaviour may be complicated by switches in the dominance hierarchy, possibly due to abundant food, and by variation in begging success occurring throughout both single feeding episodes, and the entire fledging period.

Social stimulation and breeding schedules: does the acoustic environment in penguin colonies influence the timing of egg-laying?

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Seabirds that breed in colonies lay their eggs earlier and more synchronously than those breeding under semi-colonial or solitary conditions. Social stimulation, derived from the presence and activities of neighbours, may accelerate and synchronize egg-laying by influencing ovarian development in breeding females. Here I report on a series of experiments which showed that: (1) the playback of courtship calls or colony sound increased the rate at which pairs of Little Penguins *Eudyptula minor* and Royal Penguins *Eudyptes schlegeli* copulated and performed courtship

displays; (2) the amount of time that Royal Penguins required to produce eggs could be reduced by using a playback system to provide subjects with colony-sound 'supplements' throughout the courtship period; and (3) the synchrony of egg-laying in groups of Royal Penguins could be enhanced by exposing subjects to playback of colony sounds. The experiments show that the acoustic environment in a colony influences the reproductive schedule of its occupants. The results suggest that females could advance egg-laying by settling in acoustically stimulating areas of colonies and/or by selecting males that call frequently.

Emergency care, rehabilitation and captive management of Little Penguins *Eudyptula minor*

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Penguins require specialist captive management and care. Taronga Zoo cares for almost 1 000 sick and injured wild animals each year, mostly birds. The experience gained has allowed a refinement of rehabilitation techniques used on penguins. The success rate now with Little Penguins is 70 per cent. Guidelines are given for the correct handling and emergency care of Little Penguins, appropriate indoor and outside housing, stress management, nursing of sick birds, rehydration and feeding, food storage and supplements, assessment of suitability for release, timing of release, transport to release site and actual release procedures.

The ecology and management of Little Penguins on Penguin Island, Western Australia

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The ecology of Little Penguins *Eudyptula minor* has been studied at Penguin Island, Western Australia, since 1982, and continuously from 1986 onwards. The growing body of information accumulated should contribute to the overall management of this small, isolated and marginal population of penguins. The Little Penguin reaches the northern and western limit of its breeding range on Penguin Island (32°17′S, 115°41′E), 42 km south-west of Perth in Western Australia. This colony contains about 500 pairs which breed annually within the metropolitan area of a major city on the Indian Ocean. The only other colonies of comparable size in Western Australia occur near Albany and at the Recherche Archipelago, 1 000–1 500 km away in the Southern Ocean. The Little Penguins in this very isolated but long-established population are substantially larger than conspecifics in most other populations of the *Eudyptula* species-complex in Australia and New Zealand. Penguin Island, a 12.5 ha limestone island, lacks the cohesive substrate to allow many penguins there to dig burrows; most nest under bushes. The island lies only 600 m offshore from a major conurbation whose human population has grown 50 per cent in the last five years. An exposed sandbar regularly connects the island to the mainland making the penguins potentially vulnerable to disturbance from human visitors, as well as native and introduced predators. The incidence of breeding is markedly lower in those areas most disturbed by human activity. Little Penguins on Penguin Island usually lay eggs between April and November each year, rather than in the southern hemisphere spring and summer, as is more common elsewhere. Air temperatures on Penguin Island over summer often exceed 30°C, occasionally even 40°C, presumably too hot for surface-nesting penguins to breed. The timing and magnitude of breeding also appear influenced by the Leeuwin Current, a variable, warm current of low salinity water flowing southwards along the coast. The penguins eat a wide spectrum of mainly schooling fish from the shallow, coastal waters. Their diet appears similar from year to year and includes many of the fish species taken locally by commercial bait fishermen. The relatively small size and isolation of this population of Little Penguins, their surface-nesting habits and their dietary overlap with commercial fishermen all make them highly vulnerable in the face of rapidly increasing pressure from human visitors and their recreational activity. Informed management will be imperative to ensure the wellbeing, indeed the survival, of this colony.

The foraging ecology of the African Penguin, *Spheniscus demersus*

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The foraging ecology of African Penguins breeding at Marcus and Dassen Islands (South Africa) was elucidated using externally-attached cumulative time vs depth gauges and externally-attached data loggers recording bird swim speed, swim direction and dive depth. The foraging course (in three dimensions) of birds equipped with data loggers was reconstituted using vectors on the logged parameters. Additionally, some birds equipped with loggers were induced to ingest stomach temperature loggers which indicated, via dramatic temperature drops, the time of prey ingestion and the quantity ingested. Cross referencing between the two systems enabled us to determine where prey was captured and how dives where prey was actually ingested differed from other dive types.

Penguin consumption of Southern Ocean marine resources

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Macaroni and Chinstrap Penguins were the most numerous species (11.83 and 7.50 million breeding pairs, respectively), representing 45.8 per cent and 25.6 per cent of the estimated total of 23.61 million breeding pairs of penguins in the Southern Ocean Ecosystem (SOE). The total biomass of the seven species' breeding populations within the SOE was approximately 851 810 tonnes. The estimated total annual energetic demand of 5.76×10^{13} kJ required that approximately 3.55 million tonnes of fish, 13.9 million tonnes of crustaceans and 664 000 tonnes of squid were consumed annually by the seven species of penguins. Based on these estimates, approximately 1.96 million tonnes of Carbon were consumed annually within the Southern Ocean Ecosystem by penguins. South Georgia and the South Sandwich Island, both in the South Atlantic sector of the SOE, were the primary sites for prey consumption and energy flux to penguins. The Iles Crozets, Iles Kerguelen and Heard Island and the McDonald Islands in the Indian Ocean were the next most important sites.