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# Proceedings of the Oamaru Penguin Symposium 2003

# Abstracts of papers presented at the 4th Symposium, held at the Quality Hotel Brydone, Oamaru, New Zealand, 19 and 20 June 2003

Publication of these abstracts does not preclude publication of the full paper elsewhere.

## KEYNOTE ADDRESS:

### How do little blue penguins "validate" the information contained in their aggressive displays?

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Animals may avoid fights and other forms of dangerous combat by using signals to contest resources. However, to be reliable, aggressive signals must be costly to the sender; that is, senders must invest energy in their signals. Little blue penguins (*Eudyptula minor*) may "validate" aggressive signals through past, present or, perhaps, future investment. I review empirical evidence for five types of signals that may be used by little blue penguins during conflicts. Signals based on (1) "conditioning" processes, (2) "reputation", and (3) "resource holding potential" (RHP) rely primarily on past investment. Signals validated by (4) "performance risk" (and certain RHP signals) rely on immediate investment. Finally, I discuss recent work on (5) "conventional" signals, which may be validated by costs borne in the future (e.g., as a consequence of "probing"). I conclude by arguing that each aggressive signal used by little blue penguins may represent a composite of past, present and (potentially) future costs, explaining the apparent lack of congruence between certain theoretical models and empirical evidence.

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### Abundance, breeding distribution and nesting habitat of the white flippered penguin on Banks Peninsula

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A survey of the white-flippered penguin (*Eudyptula minor albosignata*) nesting colonies on Banks Peninsula was made during the 2000/01 and 2001/02 breeding seasons. Sixty-eight colonies were found of which 51 contained 5–20 nests, 12, 21–50 nests, and 5, >50 nests. Altogether there were 2112 nests which equates to a population of c. 5870 birds. The colonies were distributed right around the peninsula with their occurrence increasing from west to east. Most were situated either on the peripheral coast (47%) or inside bays within 1 km of their entrance (38%). All but three of the colonies were on debris slopes below coastal bluffs with the nests concentrated mainly in rock piles. One colony was on an islet, and the other two were on farmland around the heads of bays. Thirty-four of the colonies were considered accessible to introduced mammalian predators, and 14 contained evidence predators had been present. The population is likely to fragment further with the eventual loss of these colonies.

### Management issues surrounding the Middle Island little penguin colony, Warrnambool, Australia

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The ecology of the little penguin (*Eudyptula minor*) breeding at Middle Island (which adjoins the west coast of Victoria) was examined over four consecutive breeding seasons from 1999 to 2003. In 1999, the vegetated upper surface of the island had 292 occupied penguin burrows at a density of 0.02/m$^2$. The colony was found to exhibit important ecological differences in breeding calendar and success, morphology, and chick growth when compared with larger colonies elsewhere in Victoria.

The colony is only 1 km from Warrnambool's City Centre and adjoins a breakwater and associated development. The island has suffered from heavy human traffic (especially tourists) as well as dog and fox predation on wildlife. Human trampling was directly responsible for 30% of chicks failing to fledge in the 1999/2000 breeding season. Over 200 adult penguins were killed in a dog attack during the 2001/02 breeding season and in the 2002/03 season, 100 adult penguins were killed by foxes over a 6-month period. The timing of these kills resulted in both chick and egg loss which had a dramatic impact on breeding success and the size of the population.

Current management strategies for the island include the installation of a boardwalk, nesting boxes, and a predator-proof fence. However, control of predators and tourists coming from the adjoining mainland has been minimal. The water surrounding the island was declared a Marine Sanctuary by the Victorian State Government in November 2002. The success of these management strategies will be discussed.

## Mate selection by blue penguins (*Eudyptula minor*)

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Nest site attendance by a group of blue penguins (*Eudyptula minor*) at Taiaroa Head, South Island, New Zealand, was studied in June 2002 during the pre-egg stage of breeding. The results of this preliminary study indicated that the process of mate selection in blue penguins differs from that of other penguin species. Mate fidelity was higher than nest site fidelity, indicating that the primary aim of both sexes was to reunite with their previous mate. Pairs changed nest sites together rather than split in order to retain a nest site. Male blue penguins moved nest sites as frequently as females. In pairs that split it was not necessarily the male that retained the nest site. Blue penguins continue to visit the colony throughout the year providing them with the opportunity to maintain pair bonds. Breeding pairs are not under the same pressure to find a mate and begin breeding as quickly as dispersive species.

Males spent significantly more nights ashore than females, due to them engaging in different activities prior to laying eggs. Males tend to compete for, defend, and prepare nest sites whereas females spend more time foraging. Pairs that had bred together previously spent more nights together at the nest site than pairs that had never bred before indicating they may begin breeding earlier. There is a potential link between breeding experience and success through an earlier onset of egg-laying in experienced individuals. Preliminary results from the study and the 2002/03 breeding season are inconclusive.

## Some findings from 529 Otago blue penguin necropsies

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Necropsy was undertaken on opportunistically collected blue penguins (*Eudyptula minor*) which had been either brought in dead or died in rehabilitation. This report is an extension of that already published upon 213 birds[1]. The additional experience has allowed attention to be drawn to the following conclusions.

1) In contrast to the modest external signs seen in the usual dog attack, a different pattern occurs with a "pack-attack", characterised by injuries

[1]Hocken, A. G. 2000: Cause of death in blue penguins (*Eudyptula m.minor*) in North Otago, New Zealand. *New Zealand Journal of Zoology 27*: 305–309.

inflicted by a (usually) single mutilating bite, associated with shaking, commonly resulting in fracture-dislocation of the cervical spine. This occurs with more than one dog "on a rampage".
2) Mustelids (ferrets) *do* kill penguins, as opposed to just scavenging corpses.
3) The mustelid killing bite is canine tooth penetration of the sub-occipital (high) cervical spine, inflicting damage to the underlying vital centres of the central nervous system.
4) Various forms of respiratory aspergillosis are the most frequent cause of naturally occurring morbidity.
5) Speculation upon the role of gastroliths must be widened by its occurrence in only 5.5% blue penguins (71% yellow-eyed penguins).
6) Interspecies comparisons in endo-parasitism are noted between blue penguins and yellow-eyed penguins. Gastric nematodes occurred in 1.3% of blue penguins, 34% of yellow-eyed but 80% of blue penguins were infested with renal flukes whilst none were found in 15 yellow-eyed penguins.

## Comparative diving behaviour in blue penguins, Queen Charlotte Sound and North Otago

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A comparative study of foraging ranges during the chick rearing phase of blue penguins (*Eudyptula minor*) from Motuara Island, Queen Charlotte Sound and Oamaru, North Otago, New Zealand, revealed great differences between both sites (Mattern et al. unpubl. data). Birds from Oamaru travelled much larger distances during one-day trips, whereas birds from Motuara Island stayed within a short range of their breeding colony. To compare diving behaviour, five birds on Motuara Island and six birds at Oamaru were equipped with time-depth recorders (TDRs). Compared with Oamaru, penguins from Motuara Island showed a greater number of dives per trip (mean number of dives 1165 versus 809), dived significantly deeper (mean depth 10.1 versus 6.0 m) and longer (mean dive duration 29.5 versus 22.4 seconds). Comparison of dive parameters suggest that penguins from Motuara Island search for prey at greater depths (depths <26 m) and, thus, increase foraging efforts vertically, while penguins at Oamaru tend to extend foraging efforts horizontally and dive shallower (depths <14 m). These findings correspond well with foraging ranges determined at both sites by Mattern et al. (unpubl. data) using VHF telemetry. The main factors influencing the foraging behaviour of Motuara Island penguins are thought to be prey availability and topographic features of Queen Charlotte Sound, which limit their foraging range on one-day trips. In contrast, Oamaru penguins profit from high abundance of one major prey species close to their breeding colonies. Furthermore, the penguins do not face any obvious environmental constraints (topography) when foraging and can travel large distances on one-day trips.

## Diving behaviour of little penguins (*Eudyptula minor*) at different stages of breeding at Phillip Island, Australia

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Time-depth recorders were used to examine the diving patterns of little penguins during incubation, guard and post-guard stages at Phillip Island, Australia. Over 115 000 dives were recorded from 67 birds over two breeding seasons, one of poor breeding success. Little penguins, being diurnal foragers, started foraging just before sunrise, made between 400–600 dives throughout the day and the last dive was around sunset. The depth of all dives increased as light intensities in the water increased (around midday). Little penguins typically dived to a depth

of 16 m and duration of 42 s, but males, because of their larger body size, were able to dive deeper and longer. The deepest dive recorded was 57 m and the longest lasted 112 s. Parents dived more often throughout chick-rearing than during incubation probably because they must find food for the young as well as themselves. The rate of dives made during incubation in a poor season was 34% greater than in a good season, and may be an early indicator of the season's breeding success. Penguins spent twice as much time feeding as they did searching for food, which agrees with their generalist foraging behaviour. Little penguins used the whole water column for foraging in contrast with previous studies of this species when they only used the top layer. This finding has implications for the management of resources shared by penguins and commercial fishers.

### Effects of a warm-water event on diet and breeding of blue penguins at Oamaru, New Zealand

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Blue penguins (*Eudyptula minor*) forage across the continental shelf and target small, schooling fish and squid. In January 1995 at Oamaru, New Zealand, slender sprat (*Sprattus antipodum*) accounted for 86% of estimated prey mass, with southern arrow squid (*Nototodarus sloanii*) at 11%. In January 2001, slender sprat accounted for only 18% of prey mass and was surpassed by red cod (*Pseudophycis bachus*) at 56% and arrow squid at 23%. Slender sprat is a winter-spawning, annual species. Annual abundance of their pelagic eggs increases with decreasing winter sea surface temperature (SST). Winter SST was average in 1993 and 1994 but >1°C above average in 1999 and 2000, indicative of a major warm-water (La Niña) event. Winter SST can be applied as an index of slender sprat abundance through the following 12 months. The predominance of sprat in the penguin diet in January 1995 can be regarded as normal, while their paucity in January 2001 was anomalous. The January 2001 appearance of anchovy (*Engraulis australis*) south of their normal distribution reinforces this interpretation. Breeders at Oamaru Blue Penguin Colony responded to the change in prey availability during the warm-water event with a reduction in the proportion of double breeders from 37% in 1994/95 to 7% in 2000/01. The only statistically significant differences in breeding dynamics were concomitant with this reduction: a delay in onset of laying and a 20% reduction in the average number of chicks fledged per pair. In particular, the average chick weight at fledging, the growth rate of chicks, and fledging success per nesting attempt were similar in both years.

### Dietary diversity and breeding success of little penguins

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It has been suggested that when pilchards and anchovies were poorly represented in the diet of little penguins (*Eudyptula minor*), their breeding period was delayed and breeding success was poor. Thus, years of poor breeding for little penguins were expected following two massive mortalities of pilchard in 1995 and 1998 in southern Australia. However, little penguins fed on other species and bred successfully in three of the five seasons following the 1995 pilchard mortality.

We examined the diet for 5 years and revisited 3 years of an earlier study to investigate whether factors in the penguins' diet other than the presence of a particular species (e.g., pilchard) can affect their breeding success. We examined the relationship between the diversity of prey and breeding success. Penguins had a less diverse diet in years of average to high breeding success than years of poor breeding success (= higher diversity). Within breeding seasons, prey diversity increased as the season progressed which coincided with an increase in foraging effort (longer foraging trip duration), larger intervals between chick feedings and, correspondingly, a drop in chick growth.

Low diversity associated with high breeding performance does not contradict the paradigm of little penguins being generalist foragers. Generalist birds usually become more specialised when prey density is higher (optimal diet model). Penguins may target pilchards and anchovies (optimal prey), but in their absence they will apparently target the next-most-profitable prey (sub-optimal prey) and can still breed successfully as shown in this study. Thus, the abundance of prey rather than the presence/absence of a particular prey species is important to the breeding success of little penguins.

## Novel methods for the cleansing and assessment of feathers

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A novel dry-cleansing method for the removal of contaminants from wildlife is being explored. This method originated from the discovery that finely divided iron powder has an extremely high affinity for chemical contaminants, including many different kinds of oil and oil/seawater emulsions[1]. The oil-adsorbing particles have been demonstrated to sequester up to 98% of the contaminant from a variety of matrices, including feathers—which are essentially restored to their original condition. The progression of this research from initial *in vitro* to whole bird investigations will be described. Various ongoing challenges such as weathered contamination and the development of field equipment will also be discussed.

In conjunction with this research, a novel method is being investigated to quantitatively assess feather damage. A mathematical model of the feather vane has been developed that allows a single "damage" parameter to be defined. This model suggests a high degree of sensitivity. When applied to digital images of real feathers, damaged by detergent in a controlled way in the laboratory, an excellent correlation between the "damage" parameter and the detergent concentration is observed. This method shows considerable promise for the development of a convenient and rapid assay for feather damage, based on digital imaging technology.

[1]Orbell, J. D.; Tan, E. K.; Coutts, M. C.; Bigger, S. W.; Ngeh, L. N. 1999: Cleansing oiled feathers – magnetically. *Marine Pollution Bulletin 38(3)*: 219–221.

## The effects of an oil spill at the Summerland Peninsula, Victoria (December 2001) on little penguins (*Eudyptula minor*)

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On 12 December 2001 an oil spill was observed off the southern Victorian coast at Kitty Miller Bay (38°30′S, 145°10′E), Phillip Island. The following morning oil was reported from beaches between Smiths Beach (38°30′S, 145°15′E), and Manndeville Road (38°31′S, 145°08′E), on the Summerland Peninsula, Phillip Island. The first oiled little penguin (*Eudyptula minor*) came ashore that evening. In total 445 oiled birds of three species, including 441 little penguins, were recovered or observed with oil on them. The release rate for rehabilitated penguins was 97.7%. This rate is considered high and was due to a number of factors, including the degree of oiling of the birds.

## Yellow-eyed penguin predation by mustelids: being effective with a moderate resource/effort trapping programme

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Mustelids (stoats and ferrets) contribute to yellow-eyed penguin (*Megadyptes antipodes*) loss on mainland New Zealand. This predation is irregular. Some yellow-eyed penguin breeding locations in recent times have escaped mustelid predation entirely, others have been predated lightly, and at some the predation has decimated the breeding population.

As managers of the habitats of this vulnerable species, it is important that we take a responsible stance on this matter. There is a cost in effort and resourcing of a trapping programme, but there is potentially a greater cost if we choose to do nothing about this threat, which is one of many currently reducing our natural biodiversity.

I introduced the problem, listing some recent local mustelid predation incidents, briefly discussed the value (ecologically, culturally and economically) of the yellow-eyed penguin, and then demonstrated a trapping system which is in place currently on Otago Peninsula. In addition, I described the methods of mustelid control currently being used in our local penguin habitats, and a selection of the most recent developments in the technology of trapping mustelids.

## Translocation and other conservation measures to increase the population size of yellow-eyed penguins at North Otago, New Zealand

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North Otago marks the northern limit of sustained breeding by yellow-eyed penguins (*Megadyptes antipodes*) and accounts for about 10–15% of nest numbers at South Island, New Zealand. Ongoing annual surveys began here in 1984/85, with peaks of c. 43 nests in 1985/86 and c. 51 nests in 2001/02. The three locations with greatest initial numbers accounted for 68% of nests in 1984/85 but only 22% in 2001/02. Their importance was replaced by two intensively managed locations that together accounted for 55% of nests in 2001/02. Intensive management targeted creation of nest-site habitat, mitigation of the detrimental effects of introduced predatory mammals, human disturbance and dogs, and rehabilitation of emaciated, injured or diseased birds. Treatment, rehabilitation and release of yellow-eyed penguins began in 1984 at one of these two locations, Katiki Point. Breeding here began only after a change in technique from hard release to soft release. The first nests were in 1991/92, parented by four rehabilitated and translocated birds. Numbers reached 14 nests in 2001/02, with a total of c. 103 chicks fledged to date. Excluding the four initial colonisers, rehabilitated penguins accounted for only three of the c. 36 breeding recruits. Small sample sizes to date and the lack of a control site preclude a conclusive assessment of the effectiveness of the intensive management techniques. However, in addition to an increase in nest numbers, for 6 years (1997–02) a mean of 1.46 chicks were fledged annually at Katiki Point, significantly greater than the respective 0.96 for the combined result from North Otago locations with little or no management.

## Comparison of population numbers of yellow-eyed penguins (*Megadyptes antipodes*) on Stewart Island and on adjacent cat-free islands

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During a comprehensive survey in 1999, 2000, and 2001, we investigated the number of breeding yellow-eyed penguin pairs on Stewart Island, where cats are present, and on adjacent cat-free islands. We found 79 pairs of yellow-eyed penguin breeding in 19 discrete locations on Stewart Island (4.2 pairs per location), and 99 pairs breeding in 10 discrete locations on all cat-free islands (9.9 pairs per location). There have been no large scale human induced habitat modifications on Stewart Island, or on any of its adjacent offshore islands. While the extensive coastline of Stewart Island (673 km) offers potentially large areas of breeding habitat for penguins, the highest number of breeding pairs were in fact found on predator-free Codfish Island (25 km long coastline), where a total of 61 breeding pairs were recorded. On Stewart Island, where mustelids are absent, only feral cats can cause a serious threat to penguin offspring. Results from this study suggest that feral cats may prey on yellow-eyed penguins on Stewart Island. Further work is necessary to investigate whether the observed low numbers of yellow-eyed penguins on Stewart Island are caused by feral cat predation. If so, it may be possible to develop appropriate measures to protect this penguin species from a population decline.

NOTE: This paper has been accepted for publication in the *New Zealand Journal of Ecology 27(2)*: 107–114.

## Rehabilitation of injured and starving yellow-eyed penguins (*Megadyptes antipodes*) at Katiki Point 1990–2000: a review of records

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In the period 1990–2000 some 135 yellow-eyed penguins were taken into care at Katiki Point. We reviewed the records generated by the carers of these birds and report on trends from the data. The reasons that penguins were taken into care fell into two groups: those that were starving and/or moulting, and those that had suffered some injury. Of the second group, most were injured while at sea. Birds were kept in captivity from 1 to 89 days. Most birds were given a course of antibiotics and also were fed glucose tablets. Based on increases in weights of birds in captivity there is evidence that captive husbandry has a positive effect on individuals. Very few individuals have returned to the breeding population. Recommendations are made about future directions for this work at Katiki.

## Habituation, penguin research and ecotourism: some thoughts from left field

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Impacts on penguins of researcher and tourist activity have been the subject of recent consideration and debate. Habituation, the cessation of response to previously response-invoking stimuli, has been used with certain other endangered species as a technique to promote their conservation. Such an approach to the management of penguins resident around New Zealand raises a number of potentially contentious issues. This presentation explores the links between global examples of deliberate habituation, local penguin research and ecotourism operations and considers the potential benefits and limitations of such a conservation management strategy. Differences in perception between ecotourism operators, conservation biologists and managers are outlined.

## Tourist visitor attitudes, activities and impacts at a yellow-eyed penguin breeding site on the Otago Peninsula, Dunedin, New Zealand

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Increases in visitor numbers to coastal Otago have raised concerns about effects of unregulated tourism

on yellow-eyed penguins (*Megadyptes antipodes*). Previous studies suggest that human activities may cause changes in yellow-eyed nest location, and departure and landing behaviour. At Sandfly Bay, a mainland breeding area on Otago Peninsula, visitor access is encouraged by signs, a car park, walking tracks and a viewing hide. Assessment of visitor impact on wildlife is hampered by lack of information on visitor numbers and activities. This preliminary study sought to address these questions to understand how better to manage unregulated sites so that impacts on wildlife are minimised, and wildlife-tourist experiences enhanced.

The project quantified visitor numbers, activities and attitudes at Sandfly Bay during the 2002/03 summer period. Fieldwork involved three aspects, i.e., counts of visitor numbers, mapping of visitor movements, and the application of a questionnaire.

Visitor numbers were recorded for 1-h periods during November, December, and January, during sample periods between 6 am and 10 pm. There was a general pattern of few visitors in the mornings, with peak numbers (10/h) in mid afternoon to early evening, coinciding with peak penguin activity on the beach. On average, over 670 people visit Sandfly Bay each week. Visitation concentrated during 2–9 pm, when peak numbers may reach 57/h.

A questionnaire was administered to Sandfly Bay visitors as they returned from their time on the beach. The aim was to assess visitor activities, and their attitudes to and awareness of wildlife. Just over a quarter of visitors were New Zealanders.

Visitor movements, activities and interactions with wildlife were also recorded directly. Target individuals were chosen and their paths transcribed onto a geo-referenced aerial photograph of Sandfly Bay. Maps were digitised, using ArcGIS computer software. This allowed characterisation of visitor movement profiles, and identification of regions of high activity.

## The most timorous of all? Impact of human disturbance on Humboldt penguins

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Increasing mobility and the interest of more and more people in nature experience as a recreational activity puts strong pressures on attractive species like penguins. The Humboldt penguin (*Spheniscus humboldti*)—classified as vulnerable (IUCN 2002)—is endemic to the upwelling region of the Humboldt Current along the west coast of South America. Protected areas such as the Humboldt Penguin National Reserve in Northern Chile (29.3°S, 71.5°E) suffer ever growing but scarcely managed human invasion. The reserve includes three islands with important breeding colonies of the Humboldt penguin. During the breeding seasons 2001/02 and 2002/03 we monitored breeding parameters and analysed the effect of experimental disturbance via heart rate telemetry. On Isla Damas, an important tourist destination, we determined significantly lower breeding success (0.44 chicks fledged per nest in 2001/02 and 0.13 in 2002/03) compared with colonies on Isla Choros (0.83/1.24) and Isla Chañaral (1.34) which are less frequented by humans. During nesting, undisturbed incubating penguins displayed heart rate (HR) increase of maximum 135% compared with their heart rate while resting (RHR). After all observed activities the HR fell back to RHR within less than a minute, usually within a few seconds. In contrast, when incubating penguins were disturbed e.g., by a person walking past the nest at 50 m distance their HR reached up to 196% of the RHR. Following this disturbance the birds needed recovery times of almost 19 min until the HR returned to its normal state. Even a person passing at 150 m distance provoked a significant HR increase of the observed penguin. We conclude the Humboldt penguin is extremely susceptible to human disturbance. This has to be considered when defining management guidelines.

The project has been realised in agreement with the following local organisations: CONAF—Corporación Nacional Forestal, UNORCH—Union de Ornitologos de Chile, SAG—Servicio Agricola y Ganadero, SUBPESCA—Subsecretaria de Pesca, SERNAPESCA—Servicio Naciónal de Pesca. Funding: FONDECYT 01010250, Stipendienstiftung University of Kiel, Deutsche Umwelthilfe.

## Foraging ecology of the Snares crested penguin

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In an effort to determine the foraging range and diving behaviour of the Snares crested penguin (*Eudyptes robustus*) during the incubation and early chick rearing phase of the breeding cycle, we attached Global Position System (GPS) and dive loggers to penguins at their nest sites. All devices were successfully deployed and retrieved after periods of up to 14 days. Unfortunately, due to design flaws and technical failures, no useful data were recorded.

To determine diet during the same period, 9 males and 15 females were stomach flushed on return from a foraging trip. Male penguins returning from 2-week foraging trips during the incubation phase generally had few items in their stomach, indicating that they were feeding at some distance from the island. Prey remains mainly comprised of fish (~90%, mainly benthic species such as long-snouted pipefish *Leptonotus norae*) and cephalopods (~10%) which presumably were taken close to the shore. Prey composition of females returning to feed chicks, on the other hand, were very different. One single species of krill (*Euphausia lucens*) was the most important diet component for females (~55%) while fish (~23%) and cephalopods (~22%) seem to play only a minor role.

## Prolactin levels of yellow-eyed penguins during the breeding season

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The hormone prolactin has been shown to be closely implicated in the initiation and maintenance of parental care in birds. The role of this hormone has not been investigated in yellow-eyed penguins (*Megadyptes antipodes*). Blood samples were collected from birds of known sex and laying dates in the 2000 and 2001 breeding seasons at Otago Peninsula. Blood sampling was conducted opportunistically from 60 days before laying and every 2–3 weeks after laying for up to 71 days. We re-sampled the same individuals when possible, particularly after egg laying. Plasma samples were then sent to the laboratory at University of Western Australia for prolactin assay. As in other studies, prolactin levels were generally highest during periods of parental care, incubation, and guard. Levels increased gradually during pre-egg stage through to egg laying. Females had consistently higher levels than males. Interestingly, there was a sudden noticeable increase in the variation of female prolactin levels starting on the day of laying. This pattern is the opposite of that found for levels of testosterone, which is associated with mating or aggressive behaviour. The factors controlling changes in prolactin levels and the cause of its variability among females are discussed.

## The influence of laying date and maternal age on eggshell thickness and pore density in yellow-eyed penguins (*Megadyptes antipodes*)

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In many birds, eggs laid late in the breeding season

hatch after a shorter incubation period than those laid earlier. Several factors have been tested for their influence on incubation periods. However, evidence for which mechanisms proximately cause these seasonal declines in the incubation period is contradictory. Studies on several bird species have shown that low eggshell porosity can limit the oxygen availability to the embryo, thereby reducing the rate of embryo growth in the later stages of incubation. Here we tested whether late-laid eggs of yellow-eyed penguins (*Megadyptes antipodes*) have thinner shells with a higher pore density that may allow embryos to develop more rapidly than those of earlier eggs. In these penguins incubation period decreases with female age, so we investigated whether eggshell characteristics are related to female age. We also tested whether there are differences in eggshell characteristics between first and second eggs of the same clutch. While eggshell thickness did not change with laying date, pore density increased. This suggests that embryos of late-laid eggs may be able to develop faster than those of early-laid eggs because of a greater capacity for gaseous exchange. Eggshell thickness and pore density increased with female age. While there was no relationship between shell thickness and incubation periods, increased pore density was associated with short incubation periods in first-laid eggs. Second-laid eggs had a lower pore density and overall less pores than first-laid eggs. In yellow-eyed penguins, both eggs of a clutch hatch synchronously, despite a laying interval of 3–5 days. We suggest that either a larger pore diameter or a thinner organic cuticle in second eggs is necessary to explain their shorter incubation periods relative to the first-laid eggs. Further work on eggshell porosity could provide answers to some longstanding questions about the evolutionary advantages of seasonal declines in incubation periods and the mechanisms that underlie hatching asynchrony.

**The use of morphometric measurements to sex yellow-eyed penguins**

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The yellow-eyed penguin (*Megadyptes antipodes*) is monomorphic but exhibits subtle sexual morphometric dimorphism. Information on the sexes of these birds is needed for informed management of the species and the construction of accurate population models. Until now, no method for instantly sexing yellow-eyed penguins in the field has been published. Using DNA analysis and discriminant function analysis on head and foot measurements, we tested whether adults and fledglings of yellow-eyed penguins can be sexed using morphometry. Up to 95% of adults can be correctly sexed using head and foot length. Using only foot length, 88% of fledglings can be sexed accurately. Age of fledglings was found to have an effect on morphometric variables, therefore sexing should be conducted as synchronised as possible when chicks are over 90 days of age. We recommend that error rates inherent in sexing fledglings be taken into account when publishing sex-ratio data and subsequent analyses, particularly when age of fledglings could not be determined.