



Above: An adult bird and two large chicks in an open nest. Such nests are susceptible during the day to hot temperatures, which then drop dramatically at night. Eggs and chicks are in danger from predators if the adult leaves the nest unattended.

Right: African penguins on the shoreline at Robben Island.



Researcher Jenny Griffin explains the difficulties that heat waves bring to penguins when they're breeding.

Penguins feel the heat



An active nest in an artificial nest box made of wood, with an A-frame design, a front opening, and a small opening in the back wall near the roof apex.

Photographs: Jenny Griffin

When conditions get too warm, penguins overheat and abandon their nests, especially those species living in warmer temperate regions such as those of Australasia, South America, and southern Africa. Increased temperatures due to global warming could seriously threaten their breeding patterns. To conserve these birds, we needed to find out about their nesting environments, how they react to changes in temperature, and what artificial environments could be created to help them.

African penguin at risk

The African penguin (*Spheniscus demersus*) is endemic to southern Africa and breeds along the coast from Algoa Bay in the east to the Namibian islands off the west coast. It lives in one of the warmest environments of any species of penguin. In the medium-term future it is at risk of extinction in the wild and is listed as "vulnerable" on the Red Data List.

Its population has decreased by 90% from an estimated total population of two million in the early 1900s to 170 000 a century later. At first, the reduction in numbers was mainly caused by people collecting penguin eggs for food and scraping guano. This last activity denuded most islands of the kind of substrate within which penguins burrow to protect their nests against

predators and from harsh weather during their breeding cycle. Now that these practices have been stopped, penguin numbers are limited by the availability of food and, crucially, breeding sites that suit them.

Nests for breeding success

African penguins come ashore to breed from mid-January/February and lay clutches of 1–2 eggs. During heat waves in February/March, however, they often abandon their eggs, and it is not unusual for an entire colony to leave their nests.

The penguins are adapted for life in cold-temperate waters. They have insulating fatty deposits to prevent hypothermia, and black and white colouring that provides camouflage from predators at sea. These adaptations cause problems of overheating while they are on land incubating eggs and brooding chicks during the breeding season. In southern Africa, penguins are often exposed in late summer to temperatures over 30°C – and in winter on the Namibian islands too, when hot, dry, east winds often blow from the desert.

Robben Island in Table Bay is one of the few breeding colonies of the African penguin where the population is growing. After being exterminated in the 1800s, nine pairs were observed breeding on the island in 1983. The

numbers steadily increased to over 7 000 pairs recorded in 2002, and between 1992 and 2003 the number of breeding birds more than tripled, reflecting a growth rate of 12.4% per year. This is now the second largest breeding colony of African penguins, with the capacity to expand further.

The University of Cape Town's Avian Demography Unit (ADU) is researching factors that affect the breeding success of African penguins on Robben Island, such as habitat choice, nest type, and microclimates experienced by incubating parents.

Our first concern was that removing invasive alien plants (see "Crackdown on invasive aliens" in *QUEST* vol.1, no.1) such as rooikrans, pines, and eucalyptus, which give shade and protection to nesting penguins, might reduce their breeding productivity, so we tried to assess the suitability of the nest boxes currently used in the colony as an alternative 'habitat' option should alien vegetation be targeted for eradication on Robben Island.

Second, we suspected that mass abandonment of clutches of eggs during heat waves is not entirely due to the extreme heat stress experienced by all the nest deserters. Penguins breed in dense colonies for the various benefits that big numbers provide, and they synchronize the building of nests and laying of eggs at the start of the breeding season. It seemed possible that, when their neighbours desert their nests because of exposure to high temperatures, birds nesting in cooler shady sites may do the same, not so much because of heat stress as because they then lose the security of numbers.

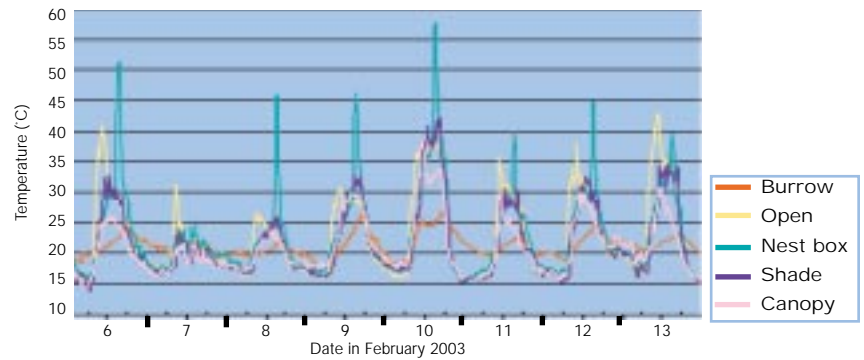
In a sample of nests of various types and different habitat we placed mini-biologgers to record temperatures at 15-minute intervals. Mean temperatures were similar in different types of nest, but the range of variation was of special interest.

Variability was greatest in artificial nest boxes, where temperatures were low at night and soared during the heat of the day – possibly owing to poor ventilation and a reduction in the mitigating effect of the cool sea breeze. Temperatures recorded in nests in burrows were more constant than in any other nest types, and these were the only nests not abandoned during a February 2003 heat wave. Temperatures in the nests situated under the shady canopy of alien eucalyptus forests showed the least variation of the nests above ground, but it was still substantially greater than in the burrow nests. Although the canopy nests do not suffer direct radiation from the sun, they are further inland and so are not cooled by the sea breezes. Given reduced air circulation, these nests still have rising temperatures during the day even though they are completely shaded.

What now?

The ADU findings echo those of a study conducted in 2002 by Yan Ropert-Coudert's team from Japan's National Institute of Polar Research on artificial nest boxes used at a breeding site of little penguins (*Eudyptula minor*) on Penguin

Fluctuations in nest temperature over time



Temperature	Burrow	Open	Nest box	Shade	Canopy
Minimum	18.0	14.9	15.6	13.8	14.3
Maximum	26.5	43.1	57.7	42.1	38.5
Mean	21.3	22.9	23.1	21.7	21.1
Standard deviation	1.8	6.8	7.0	5.9	4.5
Range	8.8	28.2	42.1	28.3	24.2



Above: Two large chicks in a burrow nest, which offers the best breeding habitat. It is shady and cool with constant temperatures and it protects eggs and small chicks from predators such as kelp gulls.

Island in Western Australia. Temperature was recorded continuously over a 37-day period inside seven nest boxes and the surrounding bush. Temperatures inside nest boxes were always higher than in the surrounding bush, with the difference between the two being greatest around noon. Differences in temperature between boxes and bushes were smaller on windy days, suggesting that better ventilation is needed in the design of nest boxes.

ADU researcher, Jessica Kemper, is examining the breeding success of African penguins on Namibian islands. She has used plastic bins cut in half and dug into the ground to form a burrow-like structure. The bins provide suitable protection from the harsh environmental conditions; they limit predation by kelp gulls, are well drained, and have ample space to accommodate two adult penguins with two large chicks. Comparing the breeding success of birds using bins with surface nesters and with those using the abandoned buildings of the guano scrapers, she found that the birds breeding in bins were more successful.

Burrows are the optimal habitat of breeding penguins, but these are scarce. Providing artificial nests may be needed to preserve penguins in an environment that is getting warmer, and these need to be carefully designed to mimic the optimal habitat found in nature. □

Jenny Griffin, a research officer at the Avian Demography Unit, University of Cape Town, is investigating factors that affect the breeding success of African penguins on Robben Island.

Changes in nest temperature (°C) of various nest types recorded over the period of a week.

Visit the ADU web site for more on its activities and research projects, and for African penguins visit its African penguin page at

http://aviandemographyunit.org/species/sp003_00 and the Southern African Foundation for Conservation of Coastal Birds (SANCCOB) at www.sanccob.co.za/African_penguin Also read R.M. Randall, "Jackass Penguins" in *Oceans of Life off Southern Africa* edited by A.I.L. Payne and R.J.M. Crawford (Halfway House: Vlaeberg, 1995), pp.34-256; and M. du Toit, L.G. Underhill, and R.J.M. Crawford, *African Penguin populations in the Western Cape, South Africa, 1992-2003*. (Cape Town: Avian Demography Unit (UCT), 2004).

For more on effects of global warming on Antarctic penguins visit <http://explorations.ucsd.edu/penguins/> and go to the National Geographic site http://news.nationalgeographic.com/news/2002/01/0117_020117antarcticpenguins for the article "Ice buildup hampers penguin breeding in Antarctica." Read the details of artificial nest experiments in Y. Ropert-Coudert, B. Cannell, and A. Kato, "Temperature inside nest-boxes of little penguin", *Wildlife Society Bulletin*, vol. 32 (2004), pp.177-182, and J. Kemper, "African penguins and rubbish bins: population dynamics and conservation in Namibia", *Bird Numbers*, vol. 10 (2001), no. 2, pp.25-26 at http://web.uct.ac.za/depts/stats/adu/bn10_2_00 For information about biologgers visit www.mcsystems.co.za (Used to monitor environmental and physiological parameters, these low-cost instruments weigh 9 g, measure 30 × 20 × 10 mm, and can record temperatures in a range from -20°C to 50°C to an accuracy of 0.2°C at intervals from 1 minute to 24 hours; the data are downloaded onto a computer to be viewed graphically.)