Inside JEB is a twice monthly feature, which highlights the key developments in *The Journal of Experimental Biology*. Written by science journalists, the short reports give the inside view of the science in JEB.

Inside JEB

HOW HUDDLES HELP PENGUINS WEATHER WINTER

Incubating a clutch of eggs can be an arduous task, even in the spring. But male emperor penguins probably endure the world's most gruelling brooding conditions, huddled together on the Antarctic ice shelf. How the males survive the extreme conditions has long intrigued biologists. In the 1950s several teams monitored the bird's mass and rectal temperature as they huddled, and in the 1990s André Ancel and Yvon Le Maho estimated their metabolic rate and suggested that 'huddling is the key factor for emperor penguins to protect themselves from the cold' says Caroline Gilbert. At the time it seemed that the males benefited from the mild temperatures at the huddle's heart, but more recent studies by Le Maho and Ancel's group have suggested that the birds may benefit in other ways. Together, Gilbert, Ancel, Le Maho and their colleague Stéphane Blanc discuss the current view of the metabolic benefits of huddling (p. 1).

Gilbert describes her experience of working with the penguins at the Dumont d'Urville base in Antarctica as 'very special'. 'There is still light as the base is close to the Antarctic circle' she explains, but admits that the environment is 'very challenging'; the high winds frequently lower the temperature to –40°C. Fitting temperature and light data loggers to huddling birds, Gilbert and her colleagues found that the birds spend 90% of their time either packed deep inside the huddle or shuffling around the edge, at relatively balmy temperatures above –10°C. The team also found previously that the birds benefit further from the huddle's warmth by lowering their body temperature and metabolic rate, saving precious fuel during their 4-month fast.

In this review, the team have calculated the huddler's metabolic savings. Knowing the mass loss pattern of birds huddling in large groups, and comparing it to the mass loss of birds in small groups (10 penguins) and isolated individuals, the team was able to calculate that huddling penguins save 26% more energy than penguins in smaller groups. Curious to know how much of the huddler's energetic savings were due to protection from the cutting wind, the team calculated the energy costs when the birds were exposed to winds at 4.9 m s^{-1} and found that gathered birds saved 32% more energy than isolated individuals. And when the team calculated the reduction in the birds' metabolic rate, they found that lowering the emperors' body temperature by 1°C contributed between 7% and 17% to their energy savings. Finally, the team considered the effect of reducing the birds' exposed surface area and found that huddling shielded a massive 74% of their surface from the elements, reducing the huddled birds' wind chill metabolic costs to 26% of an unprotected penguin.

Gilbert hopes that this new analysis of the metabolic benefits of huddling 'gives a better overview of energy savings' she says. 'In the 1950s and 70s, scientists hypothesized intuitively that warmth created inside the groups was the explanation of their energy savings' she says, but adds 'we demonstrate here that it is only one component'.

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Gilbert, C., Blanc, S., Le Maho, Y. and Ancel, A. (2008). Energy saving processes in huddling emperor penguins: from experiments to theory. *J. Exp. Biol.* **211**, 1-8.

WEIGHED BY WING BEAT

Picture by Katsufumi Sato

Katsufumi Sato is curious to know how birds get about: how they swim; how they dive; how they fly; how they glide. Which is why he was on a boat in the South Indian Ocean in 2006 studying albatrosses. At the time he wanted to know how much time these intrepid voyagers spend gliding. Sato remembers that he happened to glance out of the boat's window one day and saw a shag flying past. According to Sato he was instantly struck by how stable the flight was. It occurred to him that he might be able to estimate the bird's body mass from the frequency of the wing beat (p. 58), and what was more he already had the data that he needed to test this theory.

But the shag flight data had been collected to answer a completely different question. Sato explains that at the time he was intrigued by how diving birds propel themselves underwater with their feet and was looking for a cooperative bird on which to strap tiny accelerometers so that he could monitor their foot beat frequency. Sato struck up a collaboration with Francis Daunt and Sarah Wanless when Yutaka Watanuki and Akinori Takahashi suggested that shag would ‘make good subjects for the accelerometer’ says Sato.

Travelling to the Isle of May off the Edinburgh coast Sato, Watanuki and Takahashi monitored the diving birds with Daunt and Wanless’s help. The team weighed each bird before fitting an accelerometer and depth gauge to their backs and releasing them. As all of the birds were feeding chicks at the time, Sato recalls that the team had no problems retrieving the accelerometer at the end of a day’s foraging and could clearly see from the depth gauge records and acceleration patterns when the birds had been airborne, diving and moving on land.

Knowing that he would have plenty of time on his hands monitoring the albatrosses off Crozet Island, Sato had taken the data with him. So, when inspiration struck about a link between wing beat frequency and body mass, Sato was quickly able to put his new idea to the test.

Calculating the wing beat frequency from the acceleration data, Sato found that once steady flight had been established each bird had its own distinctive wing beat frequency. And when the birds embarked on a foraging trip, Sato noticed that the wing beat frequency increased gradually after diving. Knowing the bird’s initial mass, Sato was able to calculate the increase each time the bird returned to the air, finding that some birds only gained a few grams after diving while one gained 150 g after multiple dives. Having watched some of the birds and knowing that they usually shook themselves free of water before taking to the wing, Sato and colleagues are confident that the mass gain could be accounted for by the bird’s fish load.

‘I didn’t expect this result’ Sato admits and he is optimistic that it could help ecologists better understand birds’ interactions with their environments. For example, he explains that there is currently a conflict between Japanese fisherman and the great cormorant. The fisherman accuse the birds of plundering commercial fish stocks. Sato hopes that his new technique could lay this matter to rest by showing just how much fish a hungry cormorant consumes.

10.1242/jeb.015198

Sato, K., Daunt, F., Watanuki, Y., Takahashi, A. and Wanless, S. (2008). A new method to quantify prey acquisition in diving seabirds using wing stroke frequency. *J. Exp. Biol.* **211**, 58-65.

BIRTH ALTITUDE AFFECTS AEROBIC PERFORMANCE

High altitude rarefied atmospheres can come as a shock if you’re used to life at sea-level. No matter how hard you breathe, initially you’re left gasping. However, given time, most species adjust to the new conditions. Gregory Russell from the University of California at Riverside explains that animals living at altitude tend to have larger hearts and lungs than their sea-level relatives. Yet despite this advantage, they don’t always perform better than mice living at lower altitudes, possibly due to low oxygen levels limiting the animal’s aerobic performance. Which made Russell, Enrico Rezende and Kimberly Hammond wonder how much of an effect developmental history has on an animal’s ability to cope with different oxygen levels. The team decided to see how the aerobic performance of adult deer mice was affected by the oxygen level and altitude of their birth (p. 35).

With access to a lab-based colony of deer mice, Russell transported twenty mouse pairs to 3800 m altitude at the White Mountain Research Station ready to see how their high-born young faired relative to low-born mice. At 5 weeks of age, Russell put each of the high- and low-altitude-born mice in a treadmill and measured their aerobic performances. Then he artificially reduced the oxygen levels in the treadmill for the low-altitude mice (to simulate the effects of hypoxia at high altitude) and increased the oxygen for the high-altitude mice (simulating the effects of normoxia at low altitude) to see how they faired. The animals born in low oxygen (hypoxia) at high altitude out-performed the mice born in high oxygen (normoxia) at low altitude. At 5 weeks of age it seemed as if being born at high altitude had given the mice an advantage over the low-altitude pups.

So how would the pups born at high and low altitude adjust when transported to the opposite situation? Russell carefully transported half of the 5-week-old high-altitude pups down to the Riverside labs, and half of the Riverside pups up to the mountains, leaving the other two groups at their birth places. Giving the relocated animals 8 weeks to acclimate to their new environment, Russell again tested all of the animals’ aerobic performances in response to hypoxia and normoxia.

Amazingly, pups born at low altitude (normoxia) outperformed all of the other mice after a period of acclimation to high altitude, while the performance of pups born at high altitude (hypoxia) changed little or declined after remaining at altitude or acclimating at low altitude. The team realised that when they had tested the 5-week-old animals, the high-altitude pups must have already acclimated to the hypoxic conditions. And when the team analysed the animals’ aerobic performances, it became clear to them that there must be a physiological difference between pups gestated and born at high altitude, and pups born at low altitude. ‘How the mice accommodate the challenges imposed by high altitude depends on where they are born’ says Russell. ‘We don’t know **how** they do it’, he adds ‘but suspect that high-altitude mice acclimate in a different way’.

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Russell, G. A., Rezende, E. L. and Hammond, K. A. (2008). Development partly determines the aerobic performance of adult deer mice, *Peromyscus maniculatus*. *J. Exp. Biol.* **211**, 35-41.

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