

生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	鼻甲骨減少水分散失 (Nasal turbinates reduce water loss)
生物系統 LIVING SYSTEM	北象鼻海豹 <i>Mirounga angustirostris</i> (Northern elephant seal)
功能類別 FUNCTIONS	#獲取、吸收、或過濾液體 #保護免受液體流失危害 #Capture, absorb, or filter liquids #Protect from loss of liquids
作用機制標題	北象鼻海豹的鼻甲骨透過對流熱交換減少水分散失 (The nasal turbinates of the northern elephant seal reduce water loss via countercurrent heat exchange.)
生物系統/作用機制 示意圖	
作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)	
<p>在生殖季節時，雄性北象鼻海豹 (northern elephant seal) 經過了三個月的時間沒有食物和水分，剛斷奶的幼獸也可能有兩到三個月沒有進食。牠們唯一的水分來源是代謝儲存脂肪所產生的。因此，像乾旱環境中的動物般，牠們必須藉由減少水分散失來保存水分。</p> <p>呼吸可以是水分散失的一個重要原因。像是象鼻海豹、企鵝、馴鹿、駱駝、跳囊鼠 (kangaroo rat) 這些物種，在他們的鼻道 (nasal passage) 中，具有特別有效率的時間對流交換機制 (temporal counter-current exchange mechanism)，能將呼吸系統所散失的水分降至最低。鼻甲骨 (nasal turbinate) 是這個機制中重要的構造和功能元件。這是鼻腔通道裡一系列多骨的棚狀結構，由佈滿血管的濕潤組織和黏液覆蓋著。吸入的空氣經過這個表面會變得溫暖又濕潤，且這個表面會因為蒸發而冷卻。當動物呼氣時，來自肺部的溫暖且充滿水分的空氣經過冷卻的鼻甲骨表面，水分則在表面外凝結，因此水分會留在鼻通道內，而非散失至外界空氣中。那些能回收高比例呼吸水分的物種（例如海象的 92%，而綿羊為 24%），就具有最複雜的鼻甲骨結構。至於較精巧鼻甲骨的關鍵特徵，則是其巨大的表面積，以及表面到氣流中間的短距離。</p> <p>如象鼻海豹之類的海洋哺乳類，其鼻甲骨的設計，可提供更有效率的人造水和熱回收系統的設計靈感。</p>	

During the breeding season northern elephant seal males go without food and water for three months and weaned pups may fast for 2-3 months. Their only resource of water is that produced by metabolizing their fat stores. Therefore, like animals in arid environments, they must conserve water by minimizing water loss.

Respiration can be a significant cause of water loss. Species like the elephant seal, penguin, reindeer, camel, kangaroo rat have a particularly effective so-called temporal counter-current exchange mechanism in their nasal passages that minimizes the amount of water lost from the respiratory system. The nasal turbinates are important structural and functional components of this mechanism. This is a series of boney, shelf-like structures in the nasal passageway covered with a well-vascularized layer of moist tissue and mucus. Inhaled air passing over this surface is warmed and moistened, and the surfaces cool due to evaporation. When the animal exhales, warm, water-saturated air from the lungs passes across the cooled nasal turbinate surfaces and water condenses out of it, staying within the nasal passages rather than being lost to the outside air. Those species with the highest percentage respiratory water recovery (e.g., 92% in the elephant seal compared to 24% in the sheep), have the most complex nasal turbinate structure. The key features of the more elaborate nasal turbinates are their very large surface area and the short distance from that surface to the middle of the airstream.

Designs of nasal turbinates in marine mammals like the elephant seal may offer inspiration for the design of more effective human-constructed water and heat recapturing systems.

文獻引用 (REFERENCES)

「在陸地繁殖期間，象鼻海豹有一到三個月的時間完全沒有攝取水分和食物。鼻通道內的時間對流熱交換，可使呼出空氣的溫度 (T_e) 低於體溫 (T_b)。在 13.7°C 的平均周遭溫度時， T_e 是 20.9°C 。這將導致 71.5% 回收的水分可加到吸入的空氣中。呼出空氣 ($T_b - T_e$) 的冷卻量和水分回收的百分比，會與周遭溫度呈反向的變化。可用於熱和水交換的整個鼻腔表面區域，是位於高度曲折的鼻甲骨內，在斷奶的幼獸估計有 720 平方公分，而成年雄性則有 3140 平方公分。鼻腔的時間對流熱交換，可減少定量的總水分散失，使得只使用代謝產生的水分也能夠維持水平衡。」 (Huntly et al. 1984: 447)

“Elephant seals fast completely from food and water for 1-3 months during terrestrial breeding. Temporal countercurrent heat exchange in the nasal passage reduces expired air temperature (T_e) below body temperature (T_b). At a mean ambient temperature of 13.7°C , T_e is 20.9°C . This results in the recovery of 71.5% of the water added to inspired air. The amount of cooling of the expired air ($T_b - T_e$) and the percentage of water recovery varies inversely with ambient temperature. Total nasal surface area available for heat and water exchange, located in the highly convoluted nasal turbinates, is estimated to be 720 cm^2 in weaned pups and 3140 cm^2 in an adult male. Nasal temporal countercurrent heat exchange reduces total water loss sufficiently to allow maintenance of water balance using metabolic water production alone.”

(Huntley et al. 1984: 447)

參考文獻清單與連結 (REFERENCE LIST)

Huntley, A. C., D. P. Costa, and R. D. Rubin. (1984). The contribution of nasal countercurrent heat exchange to water balance in the northern elephant seal, *Mirounga angustirostris*. *Journal of Experimental Biology* 113: 447-454. (<https://jeb.biologists.org/content/113/1/447.abstract>)

延伸閱讀

生物系統延伸資訊連結 (LEARN MORE ABOUT THE LIVING SYSTEM/S)

https://en.wikipedia.org/wiki/Mirounga_angustirostris

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AskNature 原文連結

<https://asknature.org/strategy/nasal-turbinates-reduce-water-loss/>