生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	鯊魚眼最大化立體視覺 (Shark Eyes Maximize Stereoscopic Vision)
生物系統 LIVING SYSTEM	大鎚頭鯊 (Great hammerhead shark)
功能類別 FUNCTIONS	#感應環境中的光（可見光譜） #Sense Light (Visible Spectrum) From the Environment
作用機制標題	水平眼柄允許眼睛向前旋轉，創造更廣闊的雙眼視野 (Horizontal eye stalks allow eyes to rotate forward, creating a wider field of binocular vision)
生物系統/作用機制示意圖 (確認版權、註明出處；畫質)	 Image: Martin Prochazkacz / Shutterstock / Some rights reserved 

作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)

你可能聽過這樣一句話，“眼睛在前面，我在打獵。眼睛在一邊，我躲起來了"，這強調了大多數捕食者的眼睛都朝前這一事實，因此每隻眼睛的視野都重疊。重疊的視野被大腦同化，創造出世界的 3D 感覺，可以幫助捕食者準確判斷與獵物的距離，從而進行準確的打擊。通過將眼睛放在頭部兩側，獵物物種犧牲了立體視覺，但獲得了近 360 度的視野，這對於檢測從任何角度接近的潛在捕食者很有用。
所有的鯊魚都是捕食者，但一般來說，它們的頭部形狀和眼睛的位置只能在它們面前提供一個很小的（約 10 度）立體視野。扇形雙髻鯊（*Sphyrna lewini*）將其翻了三倍，並以 32 度的角度進行立體觀察。這是因為雖然鎚頭物種的眼睛在它們“錘子”的兩側，但在經過世的代中，隨著錘子寬度的增加眼睛已經移到了稍微向前的位置。這為鎚頭鯊提供了兩全其美的優勢：保持廣闊的視野，同時將精確深度感知的區域擴大三倍。這可能有助於雙髻鯊更好地追踪和捕捉它們捕食的快速移動的魚類。

You may have heard the phrase, “Eyes in front, I hunt. Eyes on the side, I hide,” which emphasizes the fact that most predators have their eyes facing forward, so that each eye’s visual field overlaps. The overlapping visual fields are assimilated by the brain to create a 3D sense of the world that can help predators accurately judge the distance to their prey for an accurate strike. By having their eyes on the sides of their head, prey species sacrifice stereoscopic vision but gain a nearly 360-degree visual field, useful for detecting potential predators approaching from any angle.

All sharks are predators, but in general, the shape of their heads and position of their eyes provide only a small (about 10-degree) stereoscopic visual field in front of them. The scalloped hammerhead (Sphyrna lewini) triples that and sees stereoscopically across a sweep of 32 degrees. This is due to the fact that while hammerhead species’ eyes are on the sides of their “hammers”, they have moved into a slightly more forward-facing position over the generations as the hammer increased in width. This gives hammerheads the best of both worlds: maintaining a wide field of view while tripling their area of precision depth perception. This may help hammerheads to better track and capture the fast-moving fish species they prey upon.

The Potential

鎚頭式視覺輸入可能對人類有許多有益的應用。 醫療技術經常面臨檢測小物體（如腫瘤）的挑戰，在這種情況下，更大的規模和三維度可能會減少搜索時間，同時提高準確性。

鎚頭鯊也可能為那些致力於創造大型三維體驗的人帶來一堂課。 最初受人類視覺啟發的虛擬現實 (virtual reality, VR) 正處於早期成長和實驗階段，也可以藉助其他物種的視覺系統來推動創新。 例如，模擬來自鎚頭狀眼睛位置的視覺數據的 VR 提要可以用來給我們一種擴大視野的感覺，但不會完全犧牲深度感知。

其他潛在應用包括車輛視覺傳感器的放置，它需要保持整體環境意識（例如，從任何一側接近的車輛），同時還要識別突然的近場危險（例如，穿越馬路的鹿）。

Hammerhead-style visual inputs could have many beneficial applications for humans. Medical technology is frequently challenged with detecting small objects (such as tumors) in contexts in which greater scale and three-dimensionality may reduce search time while increasing accuracy.

Hammerhead sharks may also have lessons for people who work to create large, three-dimensional experiences. Virtual reality (VR), originally inspired by human vision, is in a period of early growth and experimentation that could also look to other species' visual systems to drive innovation. For example, VR feeds that mimic visual data from hammerhead-like eye positions could be used to give us the sense of having an expanded visual field, yet without completely sacrificing depth perception.

Other potential applications include the placement of vehicle visual sensors, which need to maintain total environmental awareness (e.g., vehicles approaching from any side) while also identifying sudden, near-field hazards (e.g., a crossing deer).

文獻引用 (REFERENCES)

"這些發現表明前雙眼重疊隨著鎚頭的橫向擴張而增加。隨著頭部的擴張，扇形鎚頭鯊和翼頭鯊的眼睛已經遷移到頭葉末端更靠前的位置，並有助於增強雙眼重疊。"
"我們確定翼頭物種表現出最極端的橫向頭部擴張，具有 48 度。雙眼重疊，這比本研究中的所有物種都大，幾乎是在真鯊 (carcharhinids) 中測量的四倍。扇形鎚頭擁有 34 度。重疊，比帽頭鯊、檸檬鯊和黑鼻鯊大。為翼頭鯊和扇形鎚頭鯊確定的相對較大的雙目重疊有助於出色的深度感知。

"These findings indicate that the anterior binocular overlap has increased concomitant with the lateral expansion of the hammerheads. With head expansion the eyes of the scalloped hammerhead and winghead sharks have migrated into a more anterior position on the distal tips of the cephalofoil and facilitates the enhanced binocular overlap."
"We determined that the winghead species exhibited the most extreme lateral head expansion, possessing a 48 deg. binocular overlap, which was greater than all species in the present study and nearly fourfold that measured in the carcharhinids. The scalloped hammerhead possessed a 34 deg. overlap, which was larger than the bonnethead, lemon and blacknose sharks. The relatively large binocular overlaps determined for the winghead and scalloped hammerhead sharks facilitate excellent depth perception."

JOURNAL ARTICLE
Enhanced visual fields in hammerhead sharks
Journal of Experimental Biology | Dec. 15, 2009 | D. Michelle McComb, Timothy C. Tricas, Steven M. Kajiura

參考文獻清單與連結 (REFERENCE LIST) **Harvard 或 APA 格式**

mccomb, D. M., tricas, T. c, & Kajiura, S. M. (2009). Enhanced Visual Fields in Hammerhead Sharks. Journal of Experimental Biology, 212(24), 4010–4018.
(https://journals.biologists.com/jeb/article/212/24/4010/9615/Enhanced-visual-fields-in-hammerhead-sharks)

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