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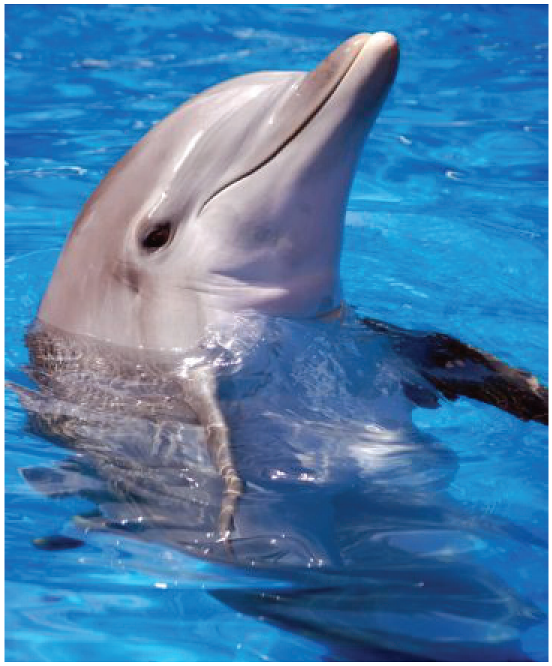
Sleeping with One Eye Open



For humans, sleep is composed of ninety minute ultradian cycles. Sleep starts with stage I sleep which is very brief before stage II sleep is seen. Sleep spindles and K complexes comprise stage II sleep. The descent continues into slow wave sleep where the electroencephalogram (EEG) slows to one to two cycles per second. After a relatively long time in slow wave sleep during the first ultradian cycle, the ascent begins back through stage II sleep before entering the low voltage and mixed frequency of rapid eye movement sleep. For humans, both cerebral hemispheres simultaneously engage in each stage of sleep and wakefulness. Things are different for some of our friends in the animal kingdom.

Cetaceans can be in slow wave sleep one cerebral hemisphere at a time. A fascinating study in the dolphin and beluga whale during unihemispheric slow wave sleep (USWS) demonstrated that the eye contralateral to the sleeping hemisphere remained primarily closed while the eye contralateral to the waking hemisphere was more often open. Bilateral eye closure during slow wave sleep was rare, occurring less than 2% of the observation time. The evolution of cetaceans and marine pinnipeds from terrestrial mammals to present forms could have involved mechanisms to ensure the avoidance of predators and the maintenance of regular breathing.[1] A similar study in a sub-adult male white whale over a 4-day-period demonstrated that this species also exhibits USWS. This study reinforced that the eye contralateral to the sleeping hemisphere in this whale is usually closed while the ipsilateral eye is typically open.[2] In contrast to the known sleep patterns of all other terrestrial mammals, like cetaceans, northern fur seals can also generate USWS.[3]

In standard sleep deprivation paradigms, sleep is either completely deprived or individual stages of sleep can be limited. In this way studies looking at the effects of either REM sleep or slow wave sleep deprivation have been performed. In regards to slow wave sleep deprivation in cetaceans, slow wave sleep can also be deprived for a single hemisphere. When this is done, slow wave sleep is allowed to occur when the animal is in USWS for one hemisphere but not for the other hemisphere. The result is that an increase in sleep pressure is observed during sleep deprivation in the deprived hemisphere. In the recovery sleep, a rebound of USWS is then seen only in the deprived hemisphere. Following bihemispheric sleep deprivation the animals exhibit an increase in delta sleep in both hemispheres.[4]

The daily need to sleep in most animals has led to the common belief that birds, such as the common swift, which spend the night on the wing, sleep in flight. As in mammals, birds exhibit both slow-wave sleep and rapid eye-movement sleep. Whereas, slow wave sleep can occur in one or both brain hemispheres at a time, REM sleep only occurs bihemispherically. During USWS, the eye connected to the awake hemisphere remains open, a state that may allow birds to visually navigate during sleep in flight. The reduction in muscle tone that usually accompanies REM sleep makes it unlikely that birds enter this state in flight. Upon landing, birds may need to recover the components of sleep that are incompatible with flight. Although formal EEG recordings have not yet been done in birds in flight, the recent miniaturization of EEG recording devices now makes it possible to measure brain activity in flight. Determining if and how birds sleep in flight will contribute to our understanding of a largely unexplored aspect of avian behavior and may also provide insight into the function of sleep.[5]

In cetaceans, unihemispheric slow wave sleep permits sleep and breathing to occur concurrently in water. For birds, unihemispheric slow wave sleep may be more important for predator detection. Sleeping for groups of mallard ducks occurs in groups of four birds arranged in a row. Birds at the ends of the row are more exposed than those in the central positions, which are flanked on both sides by other birds, and therefore may perceive a greater risk of predation. When compared to birds in the group's center, birds at the exposed ends of the row demonstrate a 150% increase in unihemispheric slow wave sleep and a preference for directing the open eye away from the group which is the direction from which a predator is most likely to approach. Furthermore, during unihemispheric slow wave sleep mallards responded rapidly to threatening visual stimuli presented to the open eye.[6]

The sum of the brainwave research in humans is that there is little evidence that either side of the brain is more or less important during REM or non-REM sleep, but instead both sides of the brain seem to be important for both kinds of sleep. Our human ancestors apparently have neither had to spend much time in nocturnal flight while migrating nor have they spent time as marine mammals swimming about with dolphins.

1 Arch Ital Biol. 2004 Jul;142(4):557-68.
2 Behav Brain Res. 2002 Feb 1;129(1-2):125-9.
3 Experientia. 1985 Aug 15;41(8):1034-5.
4 J Sleep Res. 1992 Mar;1(1):40-44.
5 Naturwissenschaften. 2006 Sep;93(9):413-25.
6 Behav Brain Res. 1999 Nov 15;105(2):163-72.