A Mammalian-like Pattern in Zebra Finch Sleep

During sleep, the zebra finch's (Taeniopygia Guttata) Robustus Archistriatalis song nucleus (RA) neurons rehearse song patterns spontaneously and respond to playback of the bird's own song. Investigation of the possible role of sleep in song learning or maintenance is hampered by the limited knowledge of sleep states in passerine birds. We therefore investigated the staging of sleep in zebra finches. To this end, we combined electrophysiological techniques with direct observation of sleeping birds. Electroencephalograms (EEGs) were obtained by recording differentially between platinum electrodes placed epidurally while using an additional electrode as a ground reference. The implants were chronic which obviated the need for restraint and pharmacological manipulation to induce sleep. During recordings, birds were bathed in infrared (IR) light and monitored with an IR camera. Mirrors facilitated detection of eye, head and body movements. Spectra of the EEG traces were computed with a multi-taper technique over 3 second increments, allowing us to identify rapid transitions in the EEG with high resolution. To date, we have preliminary results from five birds. These results indicate that zebra finches have at least three phases of sleep, which we label as rapid eye movement sleep (REM), slow wave sleep (SWS) and intermediate sleep. REM was characterized by an EEG signal typically about $\pm$ 30μV. SWS was characterized by an EEG signal with distinctly higher and broader range (up to 5 times) of amplitudes. The intermediate state was characterized by amplitudes in between REM and SWS. The REM state contained significantly less power in the Theta (4-7 Hz) range than the intermediate state which contained significantly less power in the Delta (1-4Hz) range than SWS. Slow eye movements could occur in the intermediate state whereas fast eye movements, on the order of a saccade per second, occurred only in conjunction with REM. Subtle head movements occurred often during REM. The latter tended to follow eye movements when present. During the other stages, birds breathed slowly and regularly, and any eye and head movements were synchronized to breathing. During the last hours of sleep, the REM density and average episode length was significantly increased even in birds with shifted circadian cycles. REM was never observed during unispheric sleep. We also have tentative evidence for additional physiological and behavioral complexity within the states we have identified but we have yet to perform a systematic analysis.