ble, owing to the difficulty and impracticality of teaching these processes.

The fact that transcendental meditation is easily learned and produces significant physiological changes in both beginners and advanced students gives it certain advantages over other, more austere techniques. Physiologically, the state produced by transcendental meditation seems to be distinct from commonly encountered states of consciousness, such as wakefulness, sleep, and dreaming, and from altered states of consciousness, such as hypnosis and autosuggestion. Subjective reports coupled with the physiological measurements reported above suggest that this state might have applications to clinical medicine. Transcendental meditation has been reported to have practical therapeutic value in relieving mental and physical tension (*22*). Its value in the alleviation of drug abuse has been suggested, and its value in controlling arterial blood pressure is being investigated (*23*). It could also have other applications—for instance, in space travel and in certain diseases where extended periods of low oxygen consumption that are simultaneous with responsive mental activity would be very useful.

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Paradoxical Sleep in Two Species of Avian Predator (Falconiformes)

Abstract. *Periods of disconjugate and conjugate eye movements occur during the sleep cycle in* Buteo jamaicensis arborealis *and* Herpetotheres cachinnans chapmanni. *Electromyograms are essentially isoelectric throughout sleep. Slow waves appear only in short bursts of low amplitude in contrast to the long trains of high-amplitude waves reported for chickens and pigeons.*

The behavioral and electroencephalographic (EEG) characteristics of sleep and wakefulness in birds are analogous to those reported for mammals, but differ primarily with respect to REM (rapid eye movement or paradoxical) sleep in relation to total sleep time (*1*). In the chick REM sleep comprises no

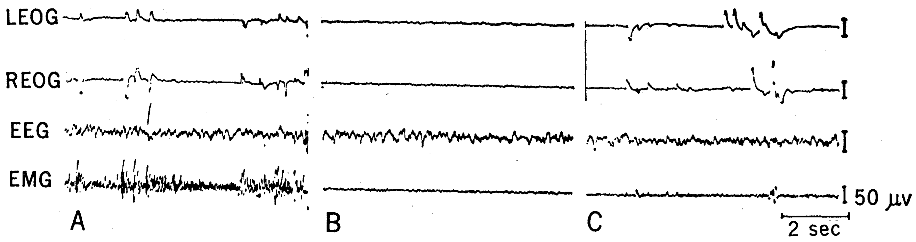

Fig. 1. Recordings showing (A) wakefulness, (B) N-REM sleep, (C) REM sleep; *LEOG*, left eye; *REOG*, right eye; *EEG*, forebrain; *EMG*, electromyogram of neck muscles.

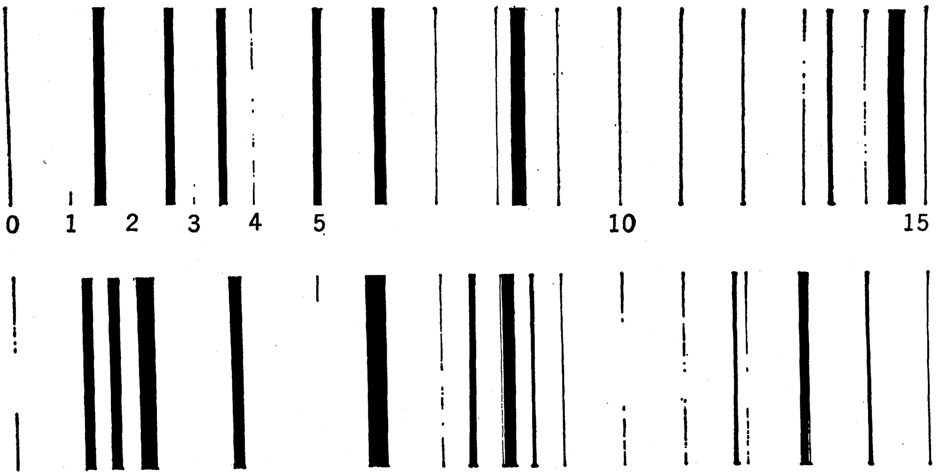

Fig. 2. Rapid eye movement (REM) during sleep in avian predators. Dark stripes represent duration in seconds of a REM burst over a period of 30 minutes. The REM bursts averaged 7 to 10 percent of total sleep time. Figure was taken from a 5 a.m. recording and is a representative sample.

more than 0.6 percent of total sleep while in the adult chicken and pigeon it comprises 0.3 percent. Hishikawa *et al.* (*2*), however, have reported 7.3 ± 1.8 percent REM sleep in young isolated chickens. To our knowledge REM percentages for other avian species have not been reported.

We studied in widely separated enclosures two young adult species of diurnal (*3*) foveate avian predators—a hawk (*Buteo jamaicensis arborealis*) and a falcon (*Herpetotheres cachinnans chapmanni*)—for 1 year and for 6 months, respectively. Under Nembutal anesthesia (15 mg/kg), tetrapolar electrodes, 0.5 mm apart and insulated except for the terminal 0.5 mm, were implanted in the cerebral hemispheres 10 mm lateral to the sagittal line. One set was implanted in the hawk, and two sets 7 mm apart in the falcon. Sites of implantation corresponded to the dorsal cortical layer and underlying hyperstriatum (*4*). Periorbital screw electrodes were implanted to record eye movements [electrooculogram (EOG)]. Two insulated stainless steel wires 1 mm in diameter were placed in the neck muscles to record the electromyogram (EMG). All wires including the ground screw were soldered to a connector affixed to the skull with dental acrylic. The EEG, EOG, and EMG were recorded on an 8-channel polygraph (Grass, model 7). Seven 24-hour recordings were made of the hawk and three 24-hour recordings were made of the falcon. Additionally, 2- to 3-hour recordings were made three times a month during nocturnal hours. Two to four weeks of recovery time was needed after the operations to yield consistent EEG activity.

Waking and sleep behavior as well as electrical recordings were similar for both birds. The bird was lightly tethered and could fly a short distance within its cage. During wakefulness the head was elevated, and constant scanning eye movements and spontaneous motor activity were present. The EEG revealed wave frequencies of 10 to 24 hz and an amplitude of 8 to 20 μv. Occasional slow waves appeared. The EOG showed frequent conjugate as well as disconjugate eye movements. The experimenter's presence consistently evoked an alerting reaction with head and body movements directed toward the source of stimulation. Sleep onset was characterized behaviorally by immobility, eye closure, and abrupt lowering of the head, followed within minutes by burying the head under a wing. As sleep deepened, the head then sank toward the floor and the wingspread increased through greater relaxation. Perching was always maintained. The EEG revealed a moderate increase in scattered slow waves of 10 to 3 hz lasting 0.1 and 0.3 second and of 25 to 40 μv irregularly spread against the background activity described for wakefulness. No long trains of slow waves were observed. There was an occasional small eye movement deflection picked up by the eye-movement leads. The EMG flattened out as soon as behavioral sleep was initiated so that the distinction between N-REM and REM sleep in terms of muscle tone was unimpressive. The REM sleep episodes were usually first observed within 4 to 8 minutes once behavioral sleep occurred (Fig. 1). Very occasionally a short REM burst appeared within 30 seconds after the precipitous drop in EMG indicative of behavioral onset of sleep. The EEG activity revealed fast frequency and low amplitude. Eye movements occurred in clusters of 7 to 15 individual high-amplitude asynchronous deflections. Less often the eye movement deflections were "yoked" (*5*). Myoclonic jerks similar to those observed in mammals were also present. The eye movement bursts lasted from 3 to 15 seconds with intervening quiescence from 30 seconds to 5 minutes, the interval infrequently being as short as 15 seconds. Arousal threshold during sleep elicited by low-tone auditory stimulus was always highest during periods of rapid eye movement activity. Periods of sleep ranged from 3 to 40 minutes with interruptions of wakefulness for periods of 5 to 10 minutes in alternating and somewhat irregular arrangement throughout the night. Thus the nocturnal sleep pattern of 6 to 8 hours was punctuated by constant wakenings such that net sleep comprised 4 to 5 hours. The REM sleep averaged 7 to 10 percent of total sleep time (Fig. 2). Neither the lower nor the upper limits of percentage of REM sleep fit consistently into any particular period of the night.

The presence of low-voltage fast activity, bursts of rapid eye movements, muscle jerks, isoelectric EMG, and increased arousal threshold constituted evidence of REM sleep in these two birds (*6*).

In view of studies indicating the presence of high-amplitude slow wave activity during sleep in the chicken and pigeon (*7*), we are puzzled that amplitude rarely exceeded 45 μv. Furthermore, this slow wave activity was even observed at times during wakefulness. Tradardi (*8*) has pointed out that the EEG patterns in birds during sleep and wakefulness were not always clearly discriminable in that slow waves could be seen in both states. However, in his case the slow waves were of high amplitude. On the other hand, EMG activity of the neck muscles in his pigeons was diminished during N-REM sleep but was not isoelectric during REM sleep, whereas EMG activity in our birds became essentially isoelectric during both phases of sleep.

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Search for an Effect of the Sun on the Frequency of 18-Centimeter Radiation

An apparent decrease in the frequency of the 21-cm absorption spectrum in Taurus A when the sun passed near the line of sight was reported by Sadeh *et al.* (*1*). This effect is not