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Sleep characteristics in the quail *Coturnix coturnix*

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HIGHLIGHTS

- The common quail (*Coturnix coturnix*) is a polyphasic animal since it sleeps at any time of the nychthemeral cycle.
- Four states of vigilance were observed in the common quail: wakefulness, drowsiness, slow wave sleep and REM sleep.
- Sleep amount showed by the common quail was significantly greater during the nocturnal period.

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ABSTRACT

As mammals, birds exhibit two sleep phases, slow wave sleep (SWS) and REM (Rapid Eye Movement) sleep characterized by presenting different electrophysiological patterns of brain activity. During SWS a high amplitude slow wave pattern in brain activity is observed. This activity is substituted by a low amplitude fast frequency pattern during REM sleep. Common quail (*Coturnix coturnix*) is an animal model that has provided information related to different physiological mechanisms present in man. There are reports related to its electrophysiological brain activity, however the sleep characteristics that have been described are not. The objectives of this study is describing the sleep characteristics throughout the nychthemeral cycle of the common quail and consider this bird species as an avian model to analyze the regulatory mechanisms of sleep. Experiments were carried out in implanted exemplars of *C. coturnix*. Under general anesthesia induced by ether inhalation, stainless steel electrodes were placed to register brain activity from the anterior and posterior areas during 24 continuous hours throughout the sleep–wake cycle. Ocular and motor activities were visually monitored. Quail showed four electrophysiologically and behaviorally different states of vigilance: wakefulness (53.28%), drowsiness (14.27%), slow wave sleep (30.47%) and REM sleep (1.98%). The animals presented 202 REM sleep episodes throughout the nychthemeral cycle. Sleep distribution was polyphasic; however sleep amount was significantly greater during the period corresponding to the night. The number of nocturnal REM sleep episodes was significantly greater than that of diurnal one.
Conclusion: The quail *C. coturnix* shows a polyphasic distribution of sleep; however the amount of this state of vigilance is significantly greater during the nocturnal period.

1. Introduction

The common quail (*Coturnix coturnix japonica*) has been an animal model in numerous fields of research. Its 17-day developmental period and the easy accessibility to embryos make this bird an adequate model for studies of developmental biology. It has been used as an animal model in multiple research laboratories for many years. It was initially suggested as a research model in 1959 by Padgett and Ivey [1], due to its "practicality" as a laboratory animal for avian developmental studies.

The Japanese quail has been also used to study many diseases that affect human health. In the field of neuroscience, the quail has been used in studies of animal learning by means of operant conditioning [2]. In contrast to mammals, the capability of birds, to regenerate the mechano-sensory hair cells in their auditory and vestibular sensory organs after damage has made the quail a useful model in the field of otolaryngology [3]. Due to its short developmental period the quail has been used as a model for studying the effect of gravity on embryonic development during short-lasting space flights [4]. On the same way due to its physiology similar to that of humans, the quail has been also considered as a useful model for studying reproductive aging of hypothalamic systems [5].

On the other hand, a large amount of the knowledge about sleep has been obtained from studies carried out in different vertebrate species, particularly in mammals [6–15].

Sleep in vertebrates, as other biological processes, has a progressive phylogenetic development, which is expressed through behavioral and

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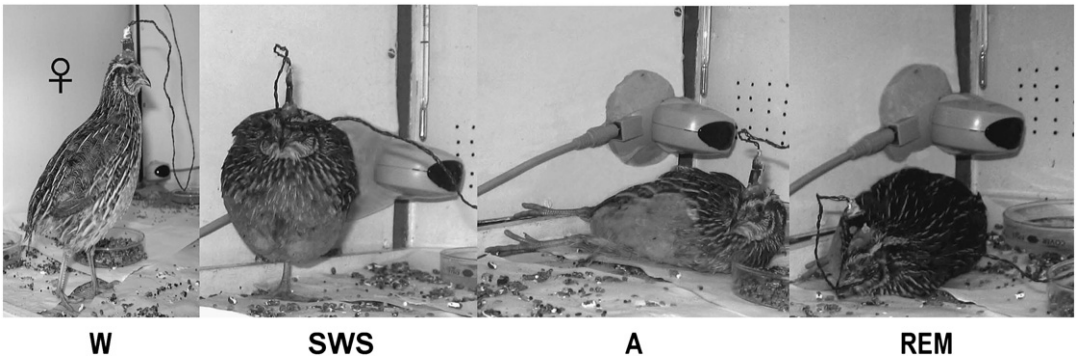

Fig. 1. States of vigilance. W = wakefulness, SWS = slow wave sleep, A = awakening, REM = rapid eye movement sleep.

electrophysiological patterns that are more or less elaborated according to the evolutionary level reached by the encephalon.

At the present time, only a minimal part of species of living vertebrates has been studied in relation to sleep. According to these studies, it has been established that mammals exhibit two phases of sleep: slow wave sleep (SWS) and rapid eye movement (REM) sleep or paradoxical sleep (PS). The first sleep phase is characterized by presenting an electrical brain activity constituted by high-voltage slow waves, while the second one presents a low-voltage fast wave pattern and REMs.

Information about sleep characteristics in birds has principally been described in pigeons [16–18] and chickens [19–29] where sleep patterns similar to those observed in mammals have been evidenced. Although there are sleep studies on other bird species [30–43], these studies are relatively scarce considering the enormous amount of living species.

As previously mentioned common quail (*Coturnix coturnix*) is an animal model that has provided information related to different physiological mechanisms present in man. Although there are reports related to its electrophysiological brain activity [44,45], the sleep patterns that have been described are not. Therefore the aim of this work is to describe the sleep patterns and consider this bird species as an avian model to analyze the regulatory mechanisms of sleep.

2. Material and methods

Experiments were carried out in 8 adult specimens of the quail *C. coturnix* of both sexes, weighing between 120 and 170 g. After 4 weeks of adaptation to recording chamber (110 × 75 × 75 cm) under an alternate period of 12 h light and 12 h darkness (Light on 8:00 h, Light off 20 h) animals were chronically implanted. Under ether anesthesia and aseptic conditions, feathers of dorsolateral cephalic regions were removed. Then, a longitudinal incision was made in the middle line of the scalp and the skull was left exposed in order to place in predetermined sites stainless steel electrodes (0.5–0.7 mm diameter) for chronic electrophysiological recordings. Two pairs of electrodes were placed on the surface of the right and left hyperstriatum for brain activity recording (EEG). Ocular and motor activities were visually and constantly monitored throughout the recordings.

Flexible wires from the electrodes were soldered to a connector fixed on the skull with acrylic cement.

Animals were allowed to recover from the surgery for at least 8 days. Polygraphic recordings were made with the animals located inside a sound-attenuated chamber, electrically shielded and constantly illuminated during the diurnal period by a 60-W white bulb in order to facilitate observation through a one-way glass window and correlate animal behavior with recordings. During the dark periods animals were observed through infrared video cameras strategically situated inside of the recording chamber. The temperature of the recording chamber oscillated between 21 and 25 °C. Food and water were constantly available. The electrophysiological activity of each animal was recorded for 24 continuous hours on a Grass Model 7 Polygraph at paper speed of 3 mm/s, with some samples at 30 mm/s during each state of vigilance.

2.1. Data analysis

Polygraphic recordings were assessed visually and scored as wakefulness (W), drowsiness (D), slow wave sleep (SWS) and REM sleep.

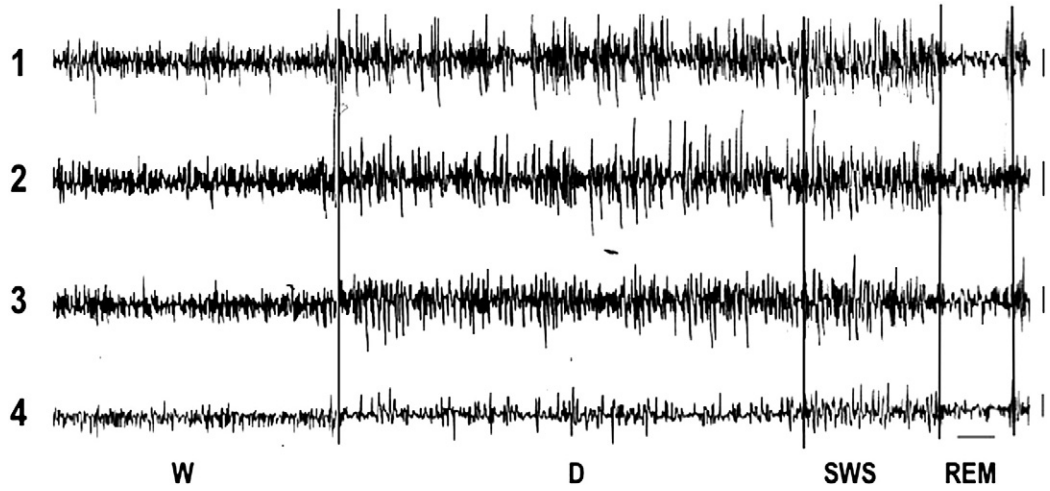

Fig. 2. Electrophysiological recoding. W = wakefulness, D = drowsiness, SWS = slow wave sleep, REM = rapid eye movement sleep. 1, Anterior hyperstriatum. 2, Posterior hyperstriatum. 3 & 4, Brain activity from the left and right hemispheres respectively. Calibration 100 μV; 2 s.