

<https://doi.org/10.30546/300045.2025.2.3.2036>

REPRODUCTIVE BEHAVIOR OF JAPANESE QUAIL (COTURNIX JAPONICA) UNDER TWO DAY AND TWO NIGHT RHYTHM

Avtandil Musayev*, Sevinj Humbatova

Baku State University, 23 Z. Khalilov St, AZ-1073, Baku, Azerbaijan

Received 14 april 2025; accepted 27 may 2025

Abstract

In natural conditions, the daily activity cycle of all galliform birds shows a bimodal pattern. The first peak occurs at sunrise (morning), and the second one in the evening (before sunset). Such patterns are observed in various behaviors (feeding, acoustic activity, aggressiveness, courtship, mating, and territory defense). In Japanese quail kept under two-day and two-night rhythms, the above-mentioned behaviors synchronize with the altered daily rhythms and are performed accordingly.

Keywords: *day; night; rhythm; reproduction; behavior; pineal gland*

1. Introduction

Due to the Earth's rotation around the Sun and its own axis, daily changes in light, temperature, tides, moon phases, and seasonal geophysical rhythms have emerged. Over millions of years, biological rhythms such as daily, monthly, seasonal, and annual rhythms have developed in accordance with these recurring geophysical cycles [3]. For all living organisms on Earth, light is the primary synchronizer. The pineal gland is a neuroendocrine organ present in all vertebrates [2, 3, 5, 6]. The pineal gland's endocrine function is physiologically regulated by the light regime. During the dark phase of the day, the synthesis of the suprachiasmatic nucleus (SCN) increases. This stimulates neurotransmitter receptors and in turn triggers the synthesis of melatonin, the main hormone of the pineal gland. Light reduces the production of this hormone. Therefore, in vertebrates, melatonin levels are low during the day and high at night [4].

Based on this understanding, the reproductive activity of Japanese quail kept under an astronomical day with two day and two night rhythms was studied.

2. Materials and Methods

The daily lighting regime was applied to Japanese quail of the same age group. The quail in the experimental group were exposed to the following daily lighting schedule: First night: from 00:00 to 04:00; First day: from 04:00 to 12:00; Second night: from 12:00 to 16:00; Second day: from 16:00 to 24:00. Control groups of quail were maintained under two standard lighting regimes used in poultry farming: 16 hours of continuous light (daytime) and 8 hours of darkness (night); 24 hours of continuous light.

In both groups, the transitions between phases mimicked natural conditions: 30 minutes before each night phase, the light intensity gradually decreased. Similarly, the daytime phase began with a gradual increase in light over 30 minutes.

Both the experimental and control groups (300 + 300 chicks) were incubated from eggs laid by quail of the same age. Once hatched, the chicks were separated into experimental and control groups. Observations were conducted on 84 females and 16 males in each group.

Aggressiveness. In Japanese quail males kept under natural lighting, aggressive behavior peaked within two hours after sunrise (morning peak) and again two hours before sunset (evening peak). After the morning peak, aggression gradually declined and reached its minimum or ceased around 1–2 PM. The evening peak started approximately 2–2.5 hours before sunset. We found that the evening aggression peak lasted longer than the morning one. In total, 45–60% of the time spent during the morning and evening peaks was associated with aggressive behavior.

One group of quail was kept under 24-hour continuous light. In this group, aggression did not occur during all hours of the day. A third group was kept under alternating 8 hours of light, 4 hours of dark, 8 hours of light, and 4 hours of dark phases. These birds exhibited increased aggression 2–3 hours before lights were turned off, similar to birds in natural conditions.

We also found that the age of the birds affected aggression timing. In the early days of egg-laying, aggression was 39.7%, while in the mid-stage of laying, it rose to 50%. Japanese quails kept under alternating day and night phases showed similar aggression patterns to those in natural conditions, with aggression rising 2–3 hours before the start of the night phase. However, this occurred at the beginning of both night phases in experimental birds.

It is known that rooster aggression is regulated by hormones, primarily testosterone and dihydrotestosterone. In sexually mature males, the synthesis of these hormones follows a daily rhythm, with peak levels occurring during the dark phase, coinciding with the start of the dark phase in their environment.

Mating activity. Mating activity depends on the birds' housing conditions. In quails kept in cages under 24-hour daylight, mating was almost not observed in the morning. For birds housed on the floor, sexual activity had two peaks. In the morning peak, males mated with nearby females without chasing them. In the evening, as in nature, males calmly mated with nearby females. If a female resisted, the male chased her to complete mating. In 24-hour light conditions, there were no morning and evening peaks. Instead, activity increased when the birds were fed.

For quails kept under alternating day and night conditions, the day was divided into alternating active and resting periods, the length of which varied depending on the light hours. When the electric lamps began to glow, both sexes became more active. Simultaneously, males began mating behavior. This period lasted about 1.5–2 hours, during which females moved between food and water containers. Behavioral patterns repeated during both day and night phases.

During the morning peak in 24-hour light conditions, quails usually rested, preened, or looked for food or drank water. Food was not provided during those hours. When food was offered, the above-mentioned behaviors resumed.

Male reproductive behavior. Among different behavior forms, sexual behavior is one of the most studied. This is because there is a direct positive correlation between mating frequency in roosters and productivity. Productivity depends on complex factors and is measured by chick viability. The productivity of hens depends on that of the roosters, and vice versa. It is known that 10–15% of incubated eggs are unfertilized, directly related to the males' sexual activity.

Sexual behavior includes many elements like feeding, displaying, and aggressive actions such as chasing, attacking, etc. It is innate and inherited. Due to rapid spermatogenesis, roosters have high sexual activity. In large flocks, the male-to-female ratio is typically 1 rooster per 8 hens. On average, a rooster mates 53 times during the daylight hours. Mating efficiency varies individually, from 19% to 87%, with some roosters reaching 90%. Incomplete mating negatively affects fertility. On average, in one flock, 23–27% of roosters have high sexual activity, 41–49% moderate, and 36–40% low.

Highly active roosters can maintain sperm viability for a long time in their reproductive tract. The physiology of this is not well understood. As mentioned earlier, frequent mating by active roosters increases egg fertilization. However, in our experiments, when active roosters were grouped together, although mating frequency was high, egg fertilization rates were low. Later research showed that sperm quality affects fertilization more than mating frequency. Experts found that after 3–4 mating, sperm viability declined, though sexual activity remained high.

Reproductive Behavior of Male and Female Quails Upon examining the morphometric measurements of female quails (hens), it was determined that passive females begin laying eggs earlier and weigh more than active ones. No differences were observed in other parameters. There were no instances of a single female mating with a rooster 3–4 times a day. Likewise, non-laying females were not observed mating with roosters. From this, it can be concluded that mating in females is related to egg-laying. The later the females begin laying, the later they begin mating. Thus, in egg-laying females, because egg-laying occurs frequently, mating also occurs intensively. In other words, egg-laying females develop a stronger desire to mate more frequently. Therefore, we can conclude that there is a direct proportional relationship between the intensity of egg-laying and the frequency of mating.

Young chicks that have just begun laying or are expected to begin within 10–15 days exhibit an increase in mating with roosters. Productivity is higher in females that mate every day or every other day. Research has shown that 3–6% of females in a flock are always ready to mate. Such individuals in the flock reduce overall productivity.

Observations of sexual activity in females revealed that they could also be divided into two groups: active and passive. Active females crouch in front of roosters more frequently, while passive ones do so less often. Roosters mated with active females 74–89% of the time. Early egg-laying by passive females led to a higher number of unfertilized eggs, thus reducing overall productivity.

In natural conditions, the courtship behavior associated with mating consists of complex stages. If the mating display by the female ends with crouching in front of the rooster, the courtship in roosters involves multiple stages. By tagging each female, we determined their individual mating frequency. The vast majority of females mate once a day—65.6–73.4%. A very small portion—20.2–24.7%—mate twice a day. There is a connection between the female's mating desire and the frequency of egg-laying. Mating that occurs 18–30 hours before the next egg-laying significantly increases the chances of that egg being fertilized.

When comparing the sexual activity of roosters kept in cages with those kept on the floor, it was found that roosters kept on the floor were 23.7–36.9% more sexually active. While researching the effect of the number of roosters in a group on productivity, it was determined that the number of dominant roosters in a group directly and positively affects productivity. For example, roosters in a group of 16 females and 2 roosters showed 3.2–11.4% higher productivity than roosters in a group with 32 females and 4 roosters. Relationships between males and females in the group are based on dominance and submission. The key condition for productivity is that the rooster be dominant over the female.

During observations of mating behavior, roosters performed a series of behaviors during mating, such as approaching the female from behind, scratching the floor with their claws, flapping their wings, approaching the food and water containers, crowing, and courting.

Among roosters kept on the floor, females would assume the mating position in front of roosters that exhibited the above-mentioned sexual behaviors. In natural conditions, the act of mating by roosters includes the following phases: inviting the female to feed – circling around the female with drooping wings – mating – inviting to the nest. Roosters display their external appearance through wing flapping and ruffling their feathers. Females choose roosters based on their appearance.

3. Results and Discussion

Among environmental factors, various factors of day length are the dominant factor controlling the circadian rhythms of birds living in natural conditions. The day length factor adapts the behavior of birds to the constantly changing environment. [7; 15; 16; 13; 10; 14]

In birds living in natural conditions and in backyards under the influence of natural environmental factors, their growth and body formation end in autumn. Several environmental factors are lacking for birds to reproduce in the winter season. Therefore, the development of the gonads and ovulation are not recorded in birds in the winter season. In artificial conditions, the above-mentioned physiological processes are carried out by lengthening the day. As a result of the studies conducted, it was determined that when the day length is shortened, sexual maturity begins on later calendar days. [11, 12].

It has been established that the synthesis of many hormones in animals (cortisol, prolactin, gonadotropin, which regulate the functions of the gonads) is associated with the rhythms of light and darkness. These hormones regulate many physiological functions in the body. As a result of the conducted studies, it has been determined that the hormonal regulation of the light and dark phases in animals is regulated by the pineal gland. Melatonin synthesized by the pineal gland regulates endogenous rhythms. The synthesis of the melatonin enzyme stops under the influence of light, and increases in the dark. The rate of metabolic processes depends on the length of the daylight hours [8]. The continuous 16-hour light regime used in the modern poultry industry shortens the time it takes for birds raised indoors to reach sexual maturity. Under this lighting regime, the weight of chickens decreases. In the subsequent development period, the egg production of hens decreases [9]. The sexual maturity of quails raised during the two day and two night phases of the astronomical day that we apply, 8 hours of two day and 4 hours of night, develops in accordance with the new phases of the circadian rhythm. The night rhythm created in the middle of the day phase affects the birds as a natural irritant and acts as a conditioned irritant. As a result of the night created repeatedly at 12⁰⁰-16⁰⁰ hours, a conditioned reflex to time is formed in birds raised in closed conditions. [1]. The astronomical circadian rhythm, with the first day-wake 8 hours, the first night-sleep 4 hours; the second day-wake 8 hours; the second night-sleep 4 hours, does not have an inhibitory effect on the synthesis of sex hormones by the hypothalamo-pituitary system. The amount of melatonin hormone synthesized in the night rhythm of the astronomical circadian rhythm, each of which is 4 hours, changes the cycle of synthesis of gonadotropin hormones synthesized by the pituitary gland, and as a result of the alternation of the two phases, the amount of synthesized hormones increases.

Our results show that when the day-activity and night-sleep phases of natural circadian rhythms are applied as external stimuli to quails kept indoors, this factor has a stimulating effect on the activity of the central nervous and endocrine systems of Japanese quails.

In nature and in backyard environments, the daily patterns of birds—such as feeding, reproductive, and locomotor activities—decrease between 12:⁰⁰ and 16:⁰⁰ hours. Daytime sleep in birds is directly influenced by environmental disturbance factors.

During the daytime phase of the astronomical day, between 12:⁰⁰ and 16:⁰⁰ hours, conditioned reflexes developed in response to an artificially induced "first night rhythm" synchronize the reproductive activity of the experimental group of quails.

References

- [1] Məmmədova GY, Musayev AM, Əliyev ƏH. Effect of new circadian rhythms in ontogenesis on the development rate of meat quail breeds. Works of the Azerbaijani Society of Zoologists. Volume 1. Baku-Elm, 2008, pp. 686-689.
- [2] Kovalenko RI. The pineal gland in the neuroendocrine regulation system. In: Fundamentals of Neuroendocrinology. Ed. by V.G. Shalyapina and P.D. Shabanov. St. Petersburg: Elbi Sib, 2005, pp. 337-365.
- [3] Komarov FI, Rapoport SM, Malinovskaya NK, Anisimov VN. Melatonin in normal and pathological conditions. Moscow: I.D. Medpraktika, 2004, 204 pages.
- [4] Anisimov VN. The solar clock of aging. Acta Gerontol, 1995, v.45, pp. 137-150.
- [5] Arendt J. Melatonin and the Mammalian Pineal Gland. L. Chapman and Hall, 1995, 131 pages.
- [6] Djerdane Y, Charbay H, Toniton Y. Older rats are more sensitive to photoperiodic changes. Study on pineal melatonin. Exp. Gerontol, 2005, v.40, pp. 403-408.
- [7] Aschoff J. Biological rhythms. Moscow: Mir, 1984, Volume I, 412 p.; Volume II, 256 pages.
- [8] Anisimov VM. Chronometer of life // *Journal Priroda*, 2007, No. 7, pp. 3-10

- [9] Greganov AP. Effective lighting modes in a poultry house // Technological. Animal husbandry., 2008, No. 3, pp. 29-31.
- [10] Ryzhanovsky VM. The role of photoperiodic conditions of high latitudes and differentiation of the passerine bird population // Russ. Ornithol. Zhurnal. Express vyp., 2007, 16, No. 380, pp. 1307-1314.
- [11] Lorenc A, Berezzi M, Zowilska J. Internal clock versus environmental light: Circadian aspects of melatonin synthesis in the turkey pineal gland and retina // Pharmacol rept, 2005, 57, №2, c.286.
- [12] Vallone D, Lahirik K, Dickmeis T, Toulkes N. Circadian rhythms and development // Dev. Dyn. 2007, 236, №1, p.30-38 .
- [13] Mammadova GY, Musayev AM. The impact of new circadian rhythms in ontogenesis on the reproductive function of the Japanese quail (*Japonicus coturnix L*) // Institute of Physiology named after A.I. Garayev of ANAS, Collection of Scientific Works of the Azerbaijan Society of Physiologists. Problems Dyachenko V.P. Circadian bases of adaptation to seasonality in migratory birds. Ecology in Russia at the turn of the XXI century. Terrestrial ecosystems // RAS, Department of General Biology, Moscow, 1999, pp. 213-235, pp. 309-415f Physiology and Biochemistry. Baku, 2009, vol. XXVII. pp. 147-150
- [14] Helm B, Gwinner E. Timing of postjuvenile molt in African (*Saxicola torquata axillaris*) and European (*Saxicola troglodytes*, *Saxicola rubicilla*) stonechats. Effects of genetic and environmental factors // Auk., 1999, v.116, № 3, pp. 589-603
- [15] Sarkar A, Arora M. Role of photoperiod in seasonal ovarian activity of red-headed bunting (*Emberiza bruniceps*) // *J.Exp. Zool.*(India), 2001, v.4, № 1, pp. 9-20
- [16] Sudhakumari C, Haldar C. Effects of photoperiod alterations on adrenocortical, pineal and gonadal activity in nocturnal bird. *Arthene brama* and diurnal bird. *Perdicula asiatica* // *Zool.Sci.*, 2001, v.18, № 1, pp. 71-79