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EDITED BY
Stefan Halle,
Friedrich Schiller University Jena, Germany

REVIEWED BY
Daniel Stanton,
University of Florida, United States

*CORRESPONDENCE
Daniela Alberghina
dalberghina@unime.it

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A rhythmic dance: how lunar cycles influence reproductive behavior in vertebrates

Daniela Alberghina*

Department of Veterinary Science, University of Messina, Messina, Italy

This review explores how lunar-controlled rhythms influence vertebrate reproduction, bridging the gap between historical folklore and modern science. For centuries, cultural beliefs have connected the moon's phases to fertility and natural cycles. Recent chronobiological studies have uncovered more specific connections, identifying complex lunar rhythms in many aquatic species that combine daily and tidal cues to regulate behaviors like spawning and migration. While circalunar and circasemilunar clocks are known to regulate reproduction in numerous invertebrates and vertebrates, the most exciting discoveries lie ahead. In the meantime, this review aims to synthesize current scientific literature to examine how lunar rhythms specifically influence reproductive behavior in vertebrates. Analyzing studies across fish, amphibians, reptiles, birds, and mammals (including humans), this review highlights how lunar phases have discernible effects on several reproductive aspects, including courtship, ovulation, semen quality, conception, embryonic development, and parturition timing. In conclusion, the growing scientific interest in lunar influence on animal reproduction underscores its potential significance in animal biology. Further interdisciplinary research is necessary to elucidate the underlying physiological mechanisms and explore their practical applications.

KEYWORDS

circalunar rhythms, circadian clock, vertebrate reproduction, chronobiology, melatonin, tidal cues

1 Introduction

For centuries, cultures worldwide have associated the moon's phases with life and natural phenomena, particularly fertility and biological cycles. The moon's continuous cycle, which takes approximately a month to complete, creates rhythms that have been observed in biological patterns for millennia.

As the moon passes over the Earth, its gravitational field creates tidal bulges in the oceans. These bulges cause high tides as they sweep across the seas, leading to dramatic environmental changes for seashore organisms (Goodenough et al., 2009). Organisms follow diverse lunar rhythms with significantly different periods: from hourly cycles like the circatidal rhythm to monthly cycles like circalunar rhythms (Andreatta and Tessmar-

Raible, 2020). While evidence for internal tidal and lunar oscillators exists, species with well-documented "free-running" rhythms are not typically used for molecular studies (Andreatta and Tessmar-Raible, 2020). Biological timing influenced by the moon is a multi-process phenomenon. The molecular mechanisms that drive short-period biological clocks, such as tidal clocks (managing tidal rhythms) and circadian clocks (managing daily rhythms), are distinct from those that govern the longer lunar clock controlling monthly cycles (Ritter and Tessmar-Raible, 2024). Although vertebrate core clock components are broadly conserved, the retention and functional variation of duplicated clock genes across different vertebrate classes add a layer of genetic complexity to how these animals might regulate diverse environmental rhythms (Stanton et al., 2022). Organisms inherit the genetic machinery (the clock genes) that provides the capacity to establish a rhythm, but the actual rhythm observed (e.g., the specific phase of a 24-hour cycle) is entrained (or set) by local environmental factors like light, temperature, and feeding schedules (Vitaterna et al., 2019). Further research suggests that even lunar clocks with the same monthly schedule might use different mechanisms, but more data is needed to draw a definitive conclusion about how these moon-dependent biological clocks work. Researchers have observed a recurring 12-hour rhythm in mammalian gene expression and metabolism, a fascinating parallel to the circatidal rhythms of their ancient ancestors (Zhu and Liu, 2023). While modern mammals no longer experience the direct 12-hour tidal shifts that influence coastal species, this persistent rhythm raises questions about its origin. To better delineate these influences, more data is needed to determine whether these moon-dependent biological clocks are an inherited trait, driven by external lunar cues, or an emergent property of an animal's internal metabolic and behavioral cycles. The persistence of this rhythm, even without an immediate tidal cue, suggests that genetic and physiological evidence of lunar influences has been preserved in our biological makeup. This highlights a fascinating contrast: while both circalunar and circadian clocks have likely evolved multiple times, circalunar clocks are believed to have diverse mechanistic principles, whereas circadian clocks are built on similar foundational principles (Rosbash, 2009). While circalunar and circasemilunar clocks are known to regulate reproduction in numerous invertebrates and vertebrates, the most exciting discoveries lie ahead. The next ten years of research focused on the molecular basis of these lunar clocks could expose a profound unity: close mechanistic and evolutionary ties connecting all of these fundamental time-keeping mechanisms (Kaiser and Neumann, 2021). This review aims to synthesize current scientific literature to examine how lunar rhythms specifically influence courtship, mating, gestation, and birth/delivery in vertebrates, thereby bridging the gap between historical beliefs and verifiable biological phenomena. Tracing the evolutionary path of the lunar influence on reproduction across different classes of vertebrates reveals a subtle, ancestral link to these cycles. Specifically, the inquiry posed by Tessmar-Raible et al. (2011) is explored: "With the advent of new molecular insight into marine non-circadian rhythms, it is likely that we will also learn more about the correlates or remnants of these rhythms in terrestrial models. Is it possibly more than sheer coincidence that the female reproductive cycle in humans lasts around a lunar month, or could this instead reflect some regulatory left-over from our evolutionary past? In this sense, the study of rhythms in our marine relatives can shed more light onto our own evolutionary past".

This investigation is guided by two aims: first, to use the study of reproductive rhythms in our marine relatives to illuminate the evolutionary origins of other vertebrate biological timing; and second, to evaluate recent findings regarding the lunar influence on human reproduction.

2 Lunar rhythms and reproductive activity

2.1 Fish

Fish, particularly many species of marine fish, are the vertebrates that show the most explicit and widespread use of circalunar, circasemilunar, and circatidal rhythms to synchronize their spawning. The synchronous spawning observed in rabbitfish during their reproductive season is consistently linked to a specific lunar phase, demonstrating a lack of geographical variation in this reproductive cue (Takemura et al., 2004). The forktail rabbitfish (*Siganus argenteus*), which spawns in sync with the last quarter moon, shows a lunar-driven correlation with testicular hormone levels and sperm motility (Rahman et al., 2001). During the spawning season, this timing can manifest in three main cycles: a lunar cycle (spawning about every 29 days), a semi-lunar cycle (spawning about every 14 days, often around spring tides), or a tidal cycle (spawning daily, generally during high tide). For fish that exhibit these lunar-related cycles, the maturation of egg cells (oocytes) and the corresponding production of sex steroid hormones are precisely timed to align with the specific lunar or tidal events. This regulation is thought to involve the higher levels of the hypothalamus-pituitary-gonad axis, which acts as the central control system for reproduction (Takemura et al., 2010).

While it's clear that fish perceive these lunar signals through their sensory organs, the exact mechanism for translating an external lunar cue into an internal, endogenous rhythm remains a mystery. However, research suggests several potential links. Melatonin levels fluctuate with nighttime brightness, magnetic fields, and tidal cycles (Takemura et al., 2010). In a tropical fish species, moonlight inversely regulates the mRNA expression of melatonin receptors in the pineal organ. Expression levels are typically observed to be higher during the new moon and lower around the full moon, suggesting a significant role in mediating lunar-related reproductive cycles (Park et al., 2014). Changes in hydrostatic pressure (related to tides) can affect monoamine (neurotransmitter) content in the brain (Damasceno-Oliveira et al., 2007). The expression of light-sensitive clock genes changes in response to moonlight, suggesting that nocturnal brightness may help phase-shift or reset the fish's biological clock to match the lunar cycle (Takemura et al., 2010). In the grass puffer (*Takifugu* *niphobles*), the expression of key reproductive genes, such as kisspeptin and gonadotropin-inhibitory hormone and their receptors, varies with lunar and semilunar cycles, peaking during spring tides (Shahjahan et al., 2024).

2.2 Amphibians

While the profound impact of climate and seasonal factors (such as temperature and rainfall) on amphibian physiology and behavior is widely known, research increasingly points to a lunar influence on reproductive synchronization, often linked to maximizing mating success or diluting predation risk (Vignoli et al., 2014). A significant body of evidence shows that many amphibians synchronize their mass reproductive events with the peak of the lunar cycle.

Large spawning events and amplexus (mating embrace) are significantly more frequent around the full moon. This synchronization is seen across different environments: in Java, where the climate is constant year-round, both the cane toad (*Bufo melanostictus*) and the Javanese frog (*Rana cancrivora*) show a similar pattern, with most females found to be reproductively active around the full moon (Church, 1960, 1961). The synodic cycle (full-to-full moon) also influences the spring migration and breeding season of the common toad (*Bufo bufo*) (Arnfield et al., 2012). Research suggests that these full moon peaks (unimodal events) are triggered by the brightest moonlight per cycle. Only first spawning and departure dates showed no clear lunar pattern (Grant et al., 2009). In contrast to anuran mass spawning, some reproductive behaviors align with the twice-monthly peak of gravitational pull.

First sighting and peak arrival events for *Lissotriton* and *Triturus* newts occurred near both the full and new moons (bimodal events), suggesting they are driven by the gravitational cycle rather than moonlight (Grant et al., 2009). The behavioral response of the butter frog (*Leptodactylus latrans*) to the lunar cycle is believed to be associated with both reproduction synchronization and predator avoidance (Henrique and Grant, 2019). Conversely, in the threatened Kloof Frog (*Natalobatrachus bonebergi*), breeding activity decreased as lunar albedo (brightness) increased, suggesting that some species in open habitats actively avoid breeding during bright moonlit nights to evade predators (Acker-Cooper et al., 2025). The occurrence of both unimodal (moonlight) and bimodal (gravitational) events strongly suggests that amphibians utilize different lunar cues to time distinct phases of their reproductive life cycle (Grant et al., 2009).

2.3 Reptiles

Lunar influences on reptile reproductive patterns are generally less documented than those in fish or amphibians. Large groups of female taricaya turtles (*Podocnemis unifilis*), a species of freshwater turtle, nested around the full moon, likely because they rely on visual cues, such as the bright moonlight, to start nesting. This behavior is consistent with social facilitation—where an animal's behavior is influenced by the presence of others (Escalona et al., 2019).

Lunar phases significantly influence the reproductive behaviors of the green sea turtle (*Chelonia mydas*), a keystone species facing population decline. A three-year study in Veracruz, Mexico, found that both nesting and hatchling emergence peaked during new and full moon phases (Perea-Brugal et al., 2025). The study also revealed that hatchling survival was highest during the first and last quarter moons, and the incubation period varied with lunar phases. The authors emphasize that integrating lunar cycles into conservation strategies can improve habitat protection and increase hatchling success (Perea-Brugal et al., 2025).

The lunar cycle influences nesting behavior in the hawksbill sea turtle (*Eretmochelys imbricata*), with the species exhibiting specific lunar phase preferences (Nakamura et al., 2019). The inter-nesting period of the hawksbill is approximately half a lunar cycle, suggesting an expected synchronization. Oviposition was more frequent during the first and last moon quarters compared to the new moon or full moon phases. However, the study also revealed that remigrant turtles do not show a consistent preferential lunar phase across different nesting seasons, indicating that an individual does not select a previously chosen lunar phase in subsequent years. Furthermore, no relationship was found between the presence of the moon in the sky and the overall nesting activity, nor between the moon's presence and the frequency of false crawls versus successful nest crawls.

2.4 Birds

In birds, vocal activity, a key behavior for territorial defense and mate attraction, is influenced by various factors, including the lunar cycle. Similar to the Ferruginous pygmy-owl (*Glaucidium brasilianum*) (Pérez-Granados et al., 2020), studies on two species of Neotropical nightjars (the Little nightjar (*Setopagis parvula*) and the Common pauraque (*Nyctidromus albicollis*) (Pérez-Granados et al., 2021) show a strong positive correlation between vocal output and moonlight. Their vocalizations were 6 to 8 times higher during full moon nights compared to new moon nights, indicating that increased moonlight may facilitate nocturnal communication. Male African houbara bustards (*Chlamydotis undulata*, ssp. *fuertaventurae*) perform nocturnal courtship displays exclusively during a full moon (Alonso et al., 2021). This behavior is thought to be an adaptation that balances predator avoidance with the need for high visibility. These males also significantly increase their vocal display time on moonlit nights, primarily through a booming call. Visual displays are limited to a quick flash of white neck feathers and occasional display runs during copulation attempts. Future research is needed to determine if this nocturnal booming contributes significantly to the individual fitness of this and other diurnal species that vocalize at night (Alonso et al., 2021). The eagle owl (*Bubo bubo*) provides a clear example of this link between light and signaling. Eagle owls use a patch of white throat plumage as a visual signal during their vocal displays. Research shows that they use moonlight to enhance the visibility of this signal: their vocal displays are more frequent, and vocalizing owls choose higher perches on nights with more moonlight (Penteriani et al., 2010). The lunar cycle can also influence hormone levels in birds; some studies indicate that daily variations in melatonin and corticosterone might diminish during full moon periods (Tarlow et al., 2003). While melatonin is known to regulate reproductive seasonality, a direct link between lunar-induced nocturnal communication or hormonal shifts and specific reproductive events in birds requires more research. The moon's phases also impact the reproductive success of poultry. A study on a commercial farm of breeding hens, under a controlled photoperiod regime, over five years revealed a significant correlation between the lunar cycle and several key reproductive metrics. The research showed that the moon's influence was much stronger during fertilization than during laying (Fárez Marca and Quezada Llivipuma, 2024). Specifically, the waxing phase of the moon was associated with a greater number of eggs produced, a higher percentage of hatched eggs, and lower hen mortality. In contrast, the moon's effect at the time of laying was only significant for a few variables, such as the number of cracked eggs and non-hatching eggs. The lunar cycle had a much more significant influence at the time of fertilization than at the time of laying. These findings suggest that the lunar cycle can have a long-term effect on conception, impacting a range of productive parameters in fertile egg-laying hens (Fárez Marca and Quezada Llivipuma, 2024). In roosters housed under a natural photoperiod, semen quality decreases when temperature and precipitation are lower, pressure is higher, and during the new moon phase. Therefore, these environmental conditions should be avoided for sperm collection and processing (Díaz Ruiz et al., 2024).

2.5 Mammals

Comparative analysis of gestation times across 213 species of terrestrial placental mammals provide compelling statistical support for a circalunar influence on reproductive timing. Brown (1988) analyzed gestation lengths against integer multiples approximating known lunar-related rhythms (weekly, twice-monthly, and monthly). Among the test integers, the number 30 (approximating the 29.53-day lunar synodic month) was consistently the best-fit multiple to the data, significantly more often than random control sets. Further, recent studies show that the lunar cycle impacts the timing of key reproductive events across various mammalian species. The inherent complexity of mammalian reproduction poses a significant hurdle to understanding the precise mechanisms through which the lunar cycle shapes reproductive processes. Isolating the specific pathways of lunar influence is difficult due to the multifaceted interaction of neuroendocrine regulation, various environmental cues, and internal physiological events (Perea et al., 2025).

2.5.1 Proposed molecular and endocrine mechanisms

Mammalian physiology is primarily synchronized by the 24-hour circadian clock in response to light and daily cycles. However, a more subtle, recurring 12-hour rhythm in gene expression and metabolism has been detected (Wilcockson and Zhang, 2008; Zhu et al., 2018). This rhythm is hypothesized to be an evolutionary remnant of the ancient, tide-synchronized clock of our marine ancestors, suggesting a possible, though currently unclear, link to reproductive activity in mammals.

Research has therefore focused on the core molecular machinery of circadian timing as potential mediators. These include the light-regulated pineal hormone, melatonin, and the light- and magneto-sensitive molecule, cryptochrome (a component of the molecular machinery that generates circadian rhythms). Although a causal relationship has not yet been demonstrated, both molecules exhibit changes that are correlated with lunar cycles in some organisms that respond to lunar influence. The circadian pacemaker and its photoperiod-responsive mechanisms have thus been proposed as mediators of responses to lunar cycles (Wehr and Helfrich-Förster, 2021).

Melatonin has a clear and fundamental role in circadian biology, governed by its well-known daily rhythm: it is typically produced at night and its release helps regulate the sleep/wake cycle. Recent research suggests that beyond its daily cycle, melatonin levels also fluctuate with nighttime brightness, magnetic fields, and tidal cycles, indicating a potential mechanism by which it may also be involved in the perception and regulation of lunar-related reproductive periodicity. Although light is the dominant circadian *zeitgeber*, the association between the lunar cycle and sleep/circadian physiology is thought to involve mechanisms other than direct light exposure (Vyazovskiy and Foster, 2014). This is particularly true given that the low intensity of full moonlight (lux) is deemed insufficient to directly affect melatonin levels; subtle non-photic geophysical forces, such as gravity, are therefore implicated. Morphological data from rats support the existence of independent, zone-specific responses within the pineal gland, with pinealocytes in the central and peripheral regions showing distinct reactions depending on both season and lunar phase (Martínez-Soriano et al., 2002).

2.5.2 Non-primates

Cattle (*Bos taurus*) provide strong evidence for lunar influence on reproduction. Spontaneous deliveries in Holstein cows peaked just before the full moon and were lowest around the new moon, suggesting a subtle, physiologically relevant effect on gestation length (Yonezawa et al., 2016). Furthermore, tropical studies on Brahman cows (*Bos taurus indicus*) showed a strong correlation between the full and new moon and the frequency of calving, first estrus, and pregnancy, indicating a bimodal rhythm (Aguirre et al., 2021). Interestingly, in cattle, the lunar phase and season do not individually affect the sex ratio, though their interaction is significant (Abecia et al., 2016). Studies on boars and piglets (Sus scrofa domesticus) show that both season and the lunar cycle affect semen traits (including ejaculate volume, sperm concentration, and total doses) and sex ratios (Chinchilla-Vargas et al., 2018; Abecia et al., 2016).

In the wild, the Serengeti wildebeest (*Connochaetes mearnsi*) links conception to a tight, two-consecutive full moon period, a strategy thought to reduce predation risk (Sinclair, 1977). The lunar cycle also influences mating behavior in European badgers (*Meles meles*), with a significant increase in activity peaking around the new moon (Dixon et al., 2006), as well as in goats (*Capra hircus*) and mares (*Equus caballus*) (Erduran, 2025; Kollerstrom and Power, 2000). Similar to cattle, the lunar phase does not consistently alter the sex ratio in goats (Abecia et al., 2016).

Domestic dogs (*Canis familiaris*) are traditionally viewed as non-seasonal breeders, a shift hypothesized to be the product of relaxed selective pressures in domestic environments (Haase, 2000). However, seasonality remains evident in older breeds, representing a vestige of the stricter cycle seen in the wolf (Gavrilovic et al., 2008; Alberghina et al., 2024). Lunar effects include sex ratio and delivery timing: the proportion of male puppies conceived was significantly lower during the new moon than during the full moon (Alberghina et al., 2021). Delivery timing varied by parity; first-litter dogs delivered more commonly during the Waxing Moon, while those with previous litters delivered more often during the Waning Moon (Fusi et al., 2025). The controlled environments we create for ourselves and dogs likely play a significant role in weakening natural seasonal cycles. Furthermore, it should be noted that the traditional, seasonally-influenced breeding cycle of domestic dogs has been largely modified due to human management. Housing dogs indoors, for example, exposes them to a consistent, artificial light-dark cycle that fails to vary with the seasons. This constant illumination disrupts the hormonal regulation (specifically, the timing of melatonin release) that typically coordinates a dog's natural reproductive cycle (Robert et al., 2015).

In guinea pigs (*Cavia porcellus*), a long-established reproductive model (Wagner, 1976), a retrospective study found that the lunar phase at mating and calving influenced reproductive traits, including litter size, weaning success, and mortality. Calving frequency was notably higher around the new and full moon (Perea et al., 2024). The fact that these guinea pigs were housed in controlled, indoor settings, however, should be considered a limitation when extrapolating the findings to natural circalunar rhythms in wild relatives.

2.5.3 Humans

A review conducted about two decades ago concluded that, despite enduring popular belief, there was limited evidence for the regulation of human biology by the lunar cycle (Foster and Roenneberg, 2008). This consensus was largely based on the negative results of past aggregate studies. However, recent longitudinal research now challenges this view, offering a different perspective. These new observations reveal that various human processes—including menstrual, sleep-wake, and manic-depressive cycles—can synchronize with lunar rhythms (Wehr and Helfrich-Förster, 2021).

The failure of earlier methods to detect these links is likely due to the inherent variability of individual responses. The aggregate analyses used in prior investigations likely canceled out unique individual responses, resulting in false negatives. Therefore, the question of lunar influence warrants further investigation using individual-focused, longitudinal data analysis (Wehr and Helfrich-Förster, 2021).

2.5.3.1 Lunar and menstrual cycles

The potential link between the lunar cycle and the menstrual cycle is especially compelling. The lunar cycle influences sleep and melatonin levels in both adults and children (Cajochen et al., 2013; Dergaa et al., 2021; Hartstein et al., 2023), and melatonin itself plays a crucial role in oocyte maturation and embryonic development (Yong et al., 2021). Several studies indicate that menstrual day frequency is influenced by lunar phases (Cutler, 1980; Law, 1986; Helfrich-Förster et al., 2021; Ecochard et al., 2024), but the specific direction of this relationship is debated. Evidence is conflicting: one prior study using four datasets suggested women tend to menstruate during the full moon (Cutler, 1980), while a separate investigation of 826 young female volunteers found that a larger proportion of menstruations were observed near the new moon (Law, 1986). In a very recent study women's menstrual cycles recorded before 2010 (prior to the widespread adoption of LEDs and smartphones) showed significant synchronization with the Moon. In contrast, cycles recorded after 2010 coupled with the Moon primarily in January. The authors hypothesized that the powerful gravimetric forces exerted by the Moon, Sun, and Earth during January are sufficient to drive this coupling, whereas increased exposure to artificial light at night likely disrupts synchrony during the rest of the year (Helfrich-Förster et al., 2025). Beyond the menstrual cycle, the lunar influence may manifest in other rhythms. For instance, female-specific gene expression patterns following a 12-hour rhythm are more pronounced than in males, with significant reprogramming occurring in the ovary during midlife (Chen et al., 2025). Furthermore, a link between suicide and moon phase was observed in premenopausal women during the winter, though not in males, suggesting that hormonal fluctuations may make women more susceptible to lunar and seasonal factors (Meyer-Rochow et al., 2021). Seizures in women with epilepsy occur in circalunar rhythms (Quigg et al., 2008).

2.5.3.2 Conception

Conception occurs when a single sperm successfully penetrates the egg, typically in the fallopian tube, creating the zygote. While a retrospective study found minimal and statistically insignificant variations in semen parameters across the lunar cycle (Moretti et al., 2008), other literature has described a link between lunar phases and both conception timing and offspring sex.

For instance, data from Vienna (1999–2019) showed the highest frequency of conceptions occurred around the full moon (Gudziunaite and Moshammer, 2022). Regarding sex selection, more females were reported to be conceived during the new moon (Sarkar and Biswas, 2005), whereas the highest likelihood of conceiving a male occurred five days after the full moon (Onken et al., 2017).

Researchers have hypothesized that the moon's gravitational force could influence the sex ratio at conception, not only its moonlight. This influence is theorized to occur by differentially selecting for lighter Y-bearing or heavier X-bearing sperm due to their weight difference (Onken et al., 2017). This hypothesis is supported by evidence that less penetrable cervical mucus selectively favors Y sperm (Martin, 1997). However, the crucial link—whether cervical mucus density itself changes with lunar phases—remains uninvestigated.

Beyond the immediate moment of conception, lunar phases have been linked to health outcomes: one study of over 51,000 pregnant women found the lowest rate of positive Down syndrome screenings in those who started their last menstrual period during a full moon (Yan et al., 2020). There is also a notable correlation between the lunar cycle and the occurrence of spontaneous abortions (Valandro et al., 2004). The correlation between the female fertility peak and the period of decreasing illumination immediately after the full moon (Criss and Marcum, 1981) further raises questions about the subtleties of human reproductive strategy.

2.5.3.3 Birth rates

The relationship between lunar cycles and human birth rates remains controversial, with many studies failing to support the popular claim that births peak during the full moon (Margot, 2015). Multiple large-scale investigations, conducted across different countries and decades, have consistently reported negative results, challenging the notion of a lunar effect on birth timing (Kelly and Martens, 1994; Joshi et al., 1998; Staboulidou et al., 2008).

However, a study from Fukutsu, Japan, used a novel approach by analyzing a subset of 1,507 full-term, spontaneous births based on the time of day. This more detailed analysis led to findings that challenge the null hypothesis: nocturnal births showed the highest number of deliveries at or around the full moon, while diurnal births peaked at or around the new moon (Matsumoto and Shirahashi, 2020). The results suggest that natural nocturnal parturition is indeed influenced by the lunar phase, consistent with ancient belief. If these natural, nighttime births genuinely peak during the full moon, this pattern may have provided an evolutionary advantage by offering better visibility during moonlit nights (Gudziunaite and Moshammer, 2022). Nevertheless, the precise evolutionary purpose of nocturnal birth remains a topic for further research, especially when considering the critical role of significant predator threats faced by vulnerable females in hunter-gatherer societies.

2.5.3.4 Evolutionary context and seasonality

The date of Easter, which can vary by as much as six weeks, is determined by the phase of the moon (Foster and Roenneberg, 2008). Specifically, it is calculated as the first Sunday after the full moon on or after the vernal equinox (Barnett, 1949). Given the historical association of the Easter period with spring fertility, I, personally, hypothesized that the lunar-based calculation determining the date of Easter may reflect an ancestral, evolutionarily favorable reproductive signal in humans. This speculative link suggests that while humans have largely lost strict reproductive seasonality, the optimal time for conception may still subtly cluster around this spring peak, potentially resulting in a higher frequency of births approximately nine months later (e.g., around the winter solstice/Christmas).

This decline in reproductive seasonality is hypothesized to be a direct consequence of industrialization, primarily due to the increased shielding of individuals from environmental cues like temperature and, most crucially, the photoperiod (light exposure) (Foster and Roenneberg, 2008).

The month an individual is conceived also significantly modulates their susceptibility to later illness. This is increasingly attributed to the fetal or neonatal environment—a key factor in shaping the developmental program—which is highly influenced by multiple seasonal factors. Consequently, the season of conception or birth is a significant determinant of an individual's lifelong health trajectory (Foster and Roenneberg, 2008). Historical data support the influence of light shielding: In pre-industrial Spain, the seasonal conception rhythm was robust, showing a consistent March/April peak that was resilient even to war. This pattern persisted until the 1960s, when a massive industrialization campaign under Franco, featuring widespread electrification and the introduction of factories to rural areas, disrupted the rhythm (Roenneberg, 2004).

3 Conclusion

Recent studies reveal that hundreds of mouse and human genes are expressed with a 12-hour pattern. These mammalian 12-hour rhythms—including their mechanisms and functions—are increasingly linked to circatidal rhythms that enable marine animals to adapt to tides. This supports the hypothesis that the 12-hour rhythms observed in terrestrial mammals may be an evolutionary vestige of our aquatic ancestry (Emery and Gachon, 2025). The mammalian 12-hour clock may have evolved from the ancient circatidal clock, which is in turn primarily entrained by the 12-hour tidal cues orchestrated by the moon (Zhu et al., 2018).

While the exact molecular mechanisms driving many of these moon-dependent biological clocks remain largely unknown—especially when compared to the well-understood circadian clock—the clear correlations documented in various species compel further research. The inherent complexity of mammalian reproduction, which involves multifaceted neuroendocrine regulation, various environmental cues, and internal physiological events, poses a significant hurdle to isolating the precise mechanisms through which the lunar cycle shapes reproductive processes (Perea et al., 2025). Nevertheless, the current evidence points to a strong influence, with the most common scientific hypothesis suggesting a non-photic mechanism, such as gravitational or electromagnetic forces.

It is plausible that organisms can sense the periodic changes in gravity caused by the Moon's position. The human vestibular system acts as a gravity sensor, and a "gravitostat" that regulates weight has been proposed to exist in rodents. Furthermore, even plants may detect lunar gravitational cycles. These small gravitational shifts, which are strong enough to affect ocean tides, suggest that a corresponding biological sensor is conceivable (Erren et al., 2020). Ultimately, the study of lunar rhythms offers a new lens through which to understand reproductive physiology and behavior. Future studies must expand to a wider range of organisms to compare how these biological clocks have evolved and adapted, revealing the core, universal mechanisms that govern cycles across the tree of life and linking human biology to broader natural cycles.

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