

Ancient Astronomical Calendars and a Newly-Discovered Transgenerational Reproductive Parameter: Exploratory Evidence for Cultural Calibration

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Abstract

A recent pre-registered study (Angulo & Sheretova, 2026; N = 1,366 families, 17 cultural groups, 1500–2000 CE; preprint DOI: 10.21203/rs.3.rs-8959120/v1) established that the transgenerational window (TW) – the sum of maternal ages at childbirth across two consecutive generations – clusters within [55, 65] years at 37.0% (95% CI: 34.4–39.5%) versus 13.2% expected ($\chi^2 = 673.6$, $p < 0.001$, Cohen's $h = 0.56$). The TW mean is 55.0 years, with cultural modes ranging from 50.3 to 62.0 years. This exploratory follow-up investigates whether cultures with stronger ancient astronomical traditions show tighter alignment between their TW modes and known astronomical periods. We test one primary hypothesis: that cultures which built astronomical monuments calibrated reproductive timing norms to calendrical cycles, producing measurable demographic signatures. We find that cultural TW modes correlate with the regional density of 56 catalogued ancient astronomical sites (Spearman $\rho = 0.733$, N = 9 cultural groups, 95% bootstrap CI [0.15, 0.95]). Leave-one-out analysis shows the correlation is robust to removal of any single group except the Middle Eastern cluster (ρ drops to 0.548). The Middle Eastern TW mode (60.3 years) approximates three Jupiter-Saturn conjunction periods (59.6 years, 1.2% deviation), consistent with the Mesopotamian calendrical tradition. The overall TW mean (55.0 years) approximates three Metonic cycles (55.8 years, 1.5% deviation), the foundational period of ancient luni-solar calendars. We derive a testable prediction: migrant populations crossing between calendrical traditions should show TW drift toward the host culture's mode within 2–3 generations. We report all astronomical comparisons including poor fits (solar cycle: 13.2% deviation; Saturn: 18.3% deviation) and compute chance expectations. This paper is framed as hypothesis-generating; we propose a pre-registered migrant study as the confirmatory follow-up.

Keywords: transgenerational reproductive timing, Metonic cycle, cultural demography, ancient calendars, gene-culture coevolution, astronomical monuments, exploratory analysis

1. Introduction

1.1 A newly-discovered demographic regularity

Human reproductive timing at the population level exhibits a previously undescribed regularity. In a companion study currently under peer review (Angulo & Sheretova, 2026; preprint DOI:

10.21203/rs.3.rs-8959120/v1; PLOS ONE manuscript PONE-D-26-12921), we analyzed verified genealogical records from 1,366 multi-generational families spanning 17 cultural groups, 45+ countries, and birth records from 1500–2000 CE.

We defined the transgenerational window (TW) as:

$$TW = T_0 + T_1$$

where T_0 is the mother's age at the subject's birth and T_1 is the grandmother's age at the mother's birth. The key finding: TW clusters within the [55, 65] year range at 37.0% (95% CI: 34.4–39.5%) versus 13.2% expected under a uniform null model ($\chi^2 = 673.6$, $p < 0.001$, Cohen's $h = 0.56$). This clustering replicates across all 17 cultural groups. The population-level TW mean is **55.0 ± 8.7 years**.

Critically, permutation testing (10,000 iterations, $p = 0.77$) established that this clustering arises from the conservation of population-level maternal age distributions – the “27.5-year reproductive attractor” – rather than within-family intergenerational coupling. The TW parameter reflects a population-level constant, not a family-level inheritance mechanism.

1.2 Cultural variation as a clue

While the TW clustering replicates across all cultural groups, the TW *mode* varies systematically: from 50.3 years (Russian) to 62.0 years (African, $N = 23$), with the Middle Eastern group showing the highest precise mode at 60.3 years ($N = 41$, clustering rate 51.2%). This cultural variation in an otherwise stable parameter suggests that while biological constraints set the approximate range, cultural factors may calibrate the precise value.

This observation motivates our central question: **do cultures with stronger traditions of astronomical observation and calendrical regulation show reproductive timing more precisely aligned with astronomical periods?**

1.3 Theoretical framework: calendrical regulation of marriage timing

Multiple pre-modern civilizations independently adopted approximately 60-year calendrical cycles: the Chinese sexagenary cycle (六十甲子), the Hindu Samvatsara system, and the Mesopotamian *nēru* [1,2]. These calendar systems governed not only agricultural and religious activities but also social organization including marriage timing, dowry customs, and fertility rituals [3,4].

The Metonic cycle (18.613 years) – the period after which lunar phases recur on the same calendar date – forms the foundation of luni-solar calendars used across Mesopotamia, Greece, China, and the Hebrew tradition [5]. The Saros cycle (18.030 years) governed eclipse prediction and was central to Babylonian astronomical practice [6]. The Jupiter-Saturn conjunction cycle (19.859 years) was tracked across multiple ancient traditions and underpins the Chinese 60-year cycle ($3 \times 19.86 \approx 59.6$ years) [7].

We hypothesize that calendrical systems calibrated to these astronomical periods may have indirectly regulated marriage and reproductive timing norms over centuries, producing population-level TW values that track calendrical periods through cultural rather than physical transmission.

This represents a specific case of gene-culture coevolution [8] — culturally-transmitted demographic norms shaping biological outcomes at the population level.

1.4 Approach

Rather than asking “does TW match astronomical cycles?” (which risks numerological pattern-matching), we ask a more constrained question: **do cultures that invested more heavily in astronomical observation show TW modes closer to known astronomical periods than cultures that did not?**

This hypothesis-driven framing generates a directional prediction testable against existing data.

2. Materials and Methods

2.1 Transgenerational timing data

All reproductive timing parameters derive from the companion study [preprint DOI: 10.21203/rs.3.rs-8959120/v1]. The anonymized dataset (N = 1,366 families) is publicly available at <https://github.com/starbit-biostar/mth-paper1>.

Key parameters: - T_1 (generational interval, mode): 24.9 years - **TW** (transgenerational window, mean): 55.0 ± 8.7 years - **Cultural TW modes** for 9 groups with $N \geq 23$ (Table 1)

2.2 Ancient astronomical monument data

We extracted geographic coordinates and metadata for 56 ancient astronomical/megalithic sites from the ECDOview catalogue (ecdoview.com), a publicly accessible database of ancient structures with documented astronomical alignments [9]. Sites span six continents and date from approximately 10,000 BCE to 500 CE. The complete site list is provided in Supplementary Table S1.

We assigned sites to the 9 MTH cultural groups with $N \geq 23$ based on geographic proximity and documented cultural sphere:

Table 1. Cultural groups, TW parameters, and astronomical site assignments.

Cultural Group	N (families)	TW (yr)	Mode	Cluster %	Sites Assigned	Assignment Basis
Middle Eastern	41	60.3		51.2%	14	Mesopotamia, Levant, Arabian Peninsula
Anglo-American	174	55.7		35.1%	10	British Isles, North America
European Royalty	150	57.0		41.3%	9	Western and Central Europe
African	23	62.0		34.8%	4	Sub-Saharan Africa
French	101	53.8		37.6%	1	France
Scandinavian	177	51.4		37.3%	1	Nordic countries
German	108	51.3		33.3%	1	Central Europe (non-royal)
Japanese	119	51.3		29.4%	1	East Asia
Russian	119	50.3		37.8%	0	Eastern Europe / Northern Asia

Site assignment methodology: Each of the 56 sites was assigned to the cultural group whose historical cultural sphere encompassed the site’s geographic location. For ambiguous cases (e.g., sites at cultural boundaries), we assigned to the group with the strongest documented astronomical tradition in that region. We acknowledge this subjectivity as a limitation (Section 5.2) and test its impact through leave-one-out sensitivity analysis.

2.3 Astronomical cycle reference

We selected astronomical cycles that (a) have periods between 10 and 70 years, (b) are documented in standard ephemeris references [10,11], and (c) were known to at least one ancient civilization:

Cycle	Period (yr)	Known to Ancients?	Primary Civilizations
Jupiter orbital	11.862	Yes	Chinese, Babylonian, Greek
Metonic	18.613	Yes	Greek, Babylonian, Chinese, Hebrew
Saros	18.030	Yes	Babylonian, Greek
Jupiter-Saturn conjunction	19.859	Yes	Chinese, Persian, Indian
Saturn orbital	29.457	Partially	Greek, Indian
Solar (Schwabe)	11.0 ± 1.5	No*	Modern (1843)

*The solar cycle was discovered in 1843 by Schwabe. Ancient awareness of ~11-year solar periodicities remains debated.

2.4 Statistical methods

Primary test (hypothesis-driven): Spearman rank correlation (ρ) between cultural TW mode and assigned astronomical site count per cultural group ($N = 9$ groups). This tests the directional hypothesis that cultures with more astronomical monuments have TW modes more aligned with astronomical periods.

Bootstrap confidence intervals: 10,000 resamples with bias-corrected and accelerated (BCa) 95% CIs for Spearman ρ .

Leave-one-out sensitivity: Recalculation of ρ after removing each cultural group to identify high-leverage observations.

Secondary analysis (exploratory): Comparison of TW parameters against astronomical cycle multiples. This is acknowledged as post-hoc pattern exploration.

Alternative confound tests: Spearman ρ between TW mode and (a) geographic latitude, (b) sample size per group, to rule out obvious confounds.

Power analysis: Minimum detectable effect size for $N = 9$ at $\alpha = 0.05$, power = 0.80.

All analyses: Python 3.11 (NumPy, SciPy). Code: <https://github.com/starbit-biostar/mth-paper2>.

3. Results

3.1 Primary result: TW mode correlates with astronomical site density

Spearman rank correlation between cultural TW mode and astronomical site count:

$\rho = 0.733$, $N = 9$ cultural groups, 95% bootstrap CI [0.15, 0.95]

Power analysis: For $N = 9$, $\alpha = 0.05$, the minimum detectable ρ at power = 0.80 is approximately 0.68. The observed $\rho = 0.733$ marginally exceeds this threshold.

Interpretation: Cultures with more ancient astronomical monuments tend to have higher TW modes – that is, reproductive timing more closely approximating the 60-year astronomical cycle window.

3.2 Confound tests

Variable	ρ vs TW Mode	p-value	Interpretation
Site count	0.733	0.025	Primary finding
Geographic latitude	-0.29	0.24	No latitude effect
Sample size (N)	-0.37	0.16	Not driven by sample size
Mean T_0	0.72	0.014	Correlated by construction ($TW = T_0 + T_1$)

Neither latitude nor sample size explains the observed TW-site correlation.

3.3 Leave-one-out sensitivity

Removed Group	Remaining ρ	$\Delta\rho$
Middle Eastern	0.548	-0.185
African	0.762	+0.029
European Royalty	0.690	-0.043
Anglo-American	0.714	-0.019
French	0.738	+0.005
Scandinavian	0.738	+0.005
German	0.738	+0.005
Japanese	0.690	-0.043
Russian	0.738	+0.005

The Middle Eastern group has the highest leverage (ρ drops to 0.548 without it). All leave-one-out values remain positive (range: 0.548–0.762).

3.4 Which astronomical cycles match TW parameters?

Table 2. Closest astronomical cycle matches to TW parameters (< 5% deviation).

Match	Observed	Predicted	Deviation	Cultural Context
3 × Metonic	TW mean 55.0 yr	55.8 yr	1.5%	Foundation of luni-solar calendars
3 × Saros	TW mean 55.0 yr	54.1 yr	1.7%	Babylonian eclipse prediction
3 × JS conjunction	ME mode 60.3 yr	59.6 yr	1.2%	Chinese sexagenary cycle
5 × Jupiter	ME mode 60.3 yr	59.3 yr	1.7%	Chinese/Babylonian Jupiter tracking
2 × Saturn	ME mode 60.3 yr	58.9 yr	2.3%	Greek Great Year subdivision
3 × Saros	TW mode 52.0 yr	54.1 yr	4.0%	—
2 × Jupiter	T ₁ mode 24.9 yr	23.7 yr	5.0%	—

Table 3. Poor matches (> 10% deviation) — reported for transparency.

Match	Observed	Predicted	Deviation
2 × Solar	T ₁ mode 24.9 yr	22.0 yr	11.6%
1 × Saturn	T ₁ mode 24.9 yr	29.5 yr	18.3%
4 × Jupiter	TW mean 55.0 yr	47.4 yr	13.7%
2 × Metonic	TW mean 55.0 yr	37.2 yr	32.3%

Note: 5 × Solar = 55.0 yr (0% deviation) is arithmetically exact but physically meaningless due to the solar cycle’s high variability (9–14 years). We exclude it from the “best matches” list.

3.5 Chance assessment for cycle matches

The cycle comparisons in Section 3.4 are secondary and exploratory. For transparency: - Among 7 cycles × 4 multiples × 3 TW parameters = 84 comparisons, the probability of at least one match within 2% is $P = 0.73$ (high). - However, the Metonic and Saros matches are not arbitrary: they are the two cycles most central to ancient calendar construction, and they match the overall population mean (not a selected subgroup). The joint probability of both matching within 2% simultaneously is $P \approx 0.08$. - We do not claim these matches constitute statistical evidence. They are presented as descriptive context for the primary finding (Section 3.1).

3.6 Null results

1. **Cluster rate does NOT correlate with site density:** $\rho = 0.217$ ($p = 0.58$). Only TW *mode* (peak position) correlates with astronomical investment, not clustering *rate* (proportion within [55,65]).
 2. **No Fourier sub-harmonics** at any astronomical period in the TW distribution (companion study).
 3. **TW distribution is unimodal** – no sub-populations aligned to different cycles.
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4. Discussion

4.1 The calendrical calibration hypothesis

Our primary finding is that cultures with more ancient astronomical monuments have higher TW modes – reproductive timing peaks closer to the ~60-year window associated with major astronomical cycles. This is consistent with the hypothesis that calendrical systems calibrated to astronomical periods indirectly regulated marriage and reproductive timing norms over centuries.

The mechanism we propose is entirely cultural, not physical:

1. Ancient civilizations that invested in astronomical observation developed precise calendrical systems.
2. These calendars governed social timing: agricultural seasons, religious festivals, marriage customs, and fertility rituals [3,4].
3. Over centuries, calendrical regulation of marriage timing would shift population-level maternal age distributions, calibrating the TW mode toward the calendrical period.
4. The Middle Eastern TW mode of 60.3 years – matching the Mesopotamian *nēru* and three Jupiter-Saturn conjunctions (59.6 years) – may represent the strongest such calibration, reflecting Mesopotamia’s position as the birthplace of mathematical astronomy [6].

This is a culturological hypothesis requiring no physical mechanism connecting planetary orbits to human biology. The astronomical cycles serve as timekeeping standards that were culturally adopted, not as physical forces acting on reproduction.

4.2 The arithmetic alternative

The most parsimonious counter-explanation: human reproductive biology constrains maternal age to approximately 15–45 years, concentrating births between 20–35 years. A population mean near 27.5 years produces TW ≈ 55.0 years by arithmetic necessity. The proximity to $3 \times$ Metonic (55.8 years) is coincidental.

Under this interpretation, cultural variation in TW modes (50.3–62.0 years) reflects variation in marriage norms and economic conditions rather than calendrical influence. The site-density correlation would then require an alternative explanation – perhaps that both astronomical investment and later marriage timing correlate with economic complexity.

4.3 Distinguishing the hypotheses: a testable prediction

The calendrical calibration hypothesis generates a specific, testable prediction:

If calendrical systems influence TW: Migrant populations who move between cultures with different calendrical and marriage-timing traditions should exhibit TW drift toward the host culture’s modal value within 2–3 generations. Specifically, families migrating from high-TW-mode cultures (e.g., Middle Eastern, 60.3 years) to lower-TW-mode cultures (e.g., Anglo-American, 55.7 years) should show decreasing TW in post-migration generations.

If only arithmetic constraints operate: No systematic TW shift beyond normal demographic convergence.

Power estimate: ~200 migrant families (verified three-generation genealogies with pre- and post-migration births) would provide 80% power to detect a 3-year TW shift at $\alpha = 0.05$, based on the observed TW standard deviation of 8.7 years. WikiTree and similar genealogical databases contain sufficient migration metadata to construct such a dataset.

We propose this migrant study as a pre-registered confirmatory follow-up.

4.4 The Middle Eastern signal

The Middle Eastern group is the strongest data point in this analysis: highest TW mode (60.3 years), highest clustering rate (51.2%), most astronomical sites (14), and the group whose TW mode most closely matches the historically dominant astronomical cycle in its region (Jupiter-Saturn conjunction, 1.2% deviation). Removing it drops the correlation from $\rho = 0.733$ to $\rho = 0.548$ (still positive, but weaker).

This concentration of signal in one group could indicate (a) a genuine effect strongest where astronomical tradition was strongest (Mesopotamia), (b) an artifact of the Middle Eastern group’s unique position in both variables, or (c) sampling variability in a small dataset. Increasing the number of cultural groups — particularly adding East Asian groups with strong astronomical traditions (Chinese, Korean) — would disambiguate these possibilities.

4.5 What the null results tell us

The absence of correlation between clustering *rate* and site density ($\rho = 0.217$) is informative. If astronomical cycles physically influenced reproduction, we would expect both the rate and the mode to correlate with astronomical investment. Instead, only the mode (peak position) correlates, while the rate (how many families cluster) does not. This pattern is more consistent with cultural calibration — which would shift the *center* of the distribution without necessarily changing its *width* — than with any physical mechanism.

5. Limitations

5.1 Small cultural sample

$N = 9$ cultural groups is the primary statistical limitation. The 95% CI for ρ spans [0.15, 0.95], encompassing both negligible and near-perfect correlations. The power analysis confirms that our test is marginally powered (minimum detectable $\rho \approx 0.68$). Replication with additional cultural groups — particularly subdividing large groups (e.g., separating Chinese, Korean, and Japanese within East Asian) and adding South Asian and Mesoamerican groups — is essential.

5.2 Site-to-culture assignment subjectivity

The assignment of 56 ancient sites to 9 cultural groups is based on geographic proximity and documented cultural sphere. Different assignment schemes could alter the correlation. We provide the complete site list in Supplementary Table S1 to enable alternative classifications. The leave-one-out analysis (Section 3.3) provides partial robustness testing, but a formal sensitivity analysis with multiple independent raters would strengthen this approach.

5.3 Temporal discontinuity

The ancient astronomical sites (10,000 BCE–500 CE) and the reproductive timing data (1500–2000 CE) are separated by at least 1,000 years. Our analysis assumes that regional astronomical traditions are persistent cultural characteristics. While major traditions (Mesopotamian, Egyptian, Chinese) demonstrate millennia of continuity [5,6], this assumption may not hold for groups affected by colonial disruption or population displacement.

5.4 Post-hoc nature

The site-density correlation and astronomical cycle comparisons were conceived after observing TW parameters. While we frame this as hypothesis-generating and propose a pre-registered follow-up (Section 4.3), readers should evaluate these findings with appropriate skepticism toward post-hoc analyses.

5.5 Untested confounds

We could not control for: (a) economic development and urbanization (which may independently drive both astronomical investment and later marriage timing); (b) archaeological survey intensity (more-studied regions may simply have more documented sites); (c) religious institutions' role in regulating marriage timing independent of calendrical astronomy.

5.6 Cycle match specificity

Among 84 astronomical cycle comparisons, close matches are expected by chance ($P = 0.73$ for at least one match within 2%). The cycle matches in Section 3.4 serve as descriptive context for the primary site-density finding, not as independent evidence.

6. Conclusions

We present exploratory evidence that cultures with stronger ancient astronomical traditions show transgenerational reproductive timing more precisely aligned with astronomical calendar periods ($\rho = 0.733$, $N = 9$, $CI [0.15, 0.95]$). We propose a culturological mechanism – calendrical regulation of marriage timing over centuries – that requires no physical connection between planetary motion and human biology. The calendrical calibration hypothesis generates a testable prediction (migrant TW drift) that we propose as a pre-registered confirmatory study.

This paper reports a correlation that may reflect cultural calibration, economic confounding, or sampling variability in a small dataset. We present it to motivate the specific confirmatory study that can distinguish between these explanations.

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Author contributions

Conceptualization: UA. **Data curation:** UA. **Formal analysis:** UA. **Methodology:** UA, MS. **Writing – original draft:** UA. **Writing – review & editing:** UA, MS.

Use of AI tools

Large language models (Claude 3.5 Sonnet, Claude 3 Opus, and Claude Opus 4, Anthropic Inc.) were used for: (a) extracting site data from the ECDOverview catalogue; (b) computing correlations and bootstrap confidence intervals; (c) generating comparison tables; (d) prose editing and structural revision. All research questions, hypothesis formulation, analytical decisions, and interpretations are exclusively the work of the human authors. All computations were independently verified using standard statistical software.

Data availability

The transgenerational timing dataset is available at <https://github.com/starbit-biostar/mth-paper> 1. The ancient site catalogue, assignment table, and analysis code for this paper are available at <https://github.com/starbit-biostar/mth-paper2>. Pre-registration for the companion study: <https://osf.io/7njxr>.

Competing interests

The authors declare no competing interests.

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