7. Velikovsky, Immanuel. 1977. Peoples of the sea. Doubleday, Garden City, p. 207.
8. Velikovsky, Immanuel. 1952. Ages in Chaos. Doubleday, Garden City, pp. 103-05.
9. *Ibid.*, pp. 103-41.
10. *Ibid.*. p. 107.
11. *Ibid.;* pp. 155-63.
12. *Ibid.*, pp. 205-19.
13. *Ibid.*, pp. 223-340.
14. Velikovsky, Immanuel. 1960. Oedipus and Akhnaton. Doubleday, Garden City.
15. Velikovsky, Immanuel. 1978. From the end of the eighteenth dynasty to the time of Ramses II. *Kronos* III(3): 3-33.
16. Velikovsky, Immanuel. 1979. The correct placement of Haremhab in Egyptian history. *Kronos* IV(3):3-22.
17. Velikovsky, Immanuel. 1980. Cultural aspects of the Lybian and Ethiopian dynasties. *Kronos* V(3):1-10.
18. Velikovsky. Immanuel. 1984. Esarhaddon in Egypt. *Kronos* IX(3):1-15.
19. Velikovsky. *Op. cit.,* (Ramses II and his time).
20. Velikovsky. *Op. cit.,* (Peoples of the sea).
21. Courville, Donovan A. 1971. The exodus problem and its ramifications, 2 vols. Challenge Books, Loma Linda, CA.
22. Courville. Donovan A. 1974. Evolution and archaeological interpretation. *Creation Research Society Quarterly* 11: 47-56.
23. Courville, Donovan A. 1975. Is a fixed chronology of Egypt back to c. 2000 B.C. mistaken? *Creation Research Society Quarterly* 11:202-10.
24. Courville, Donovan A. 1975. A Biblical reconstruction of Egypt's chronology. *Journal of Christian Reconstruction* II(1):131-59.
25. Courville, Donovan A. 1975. Limitations of astronomical dating methods. *Kronos* I(2):49-72.
26. Courville, Donovan A. 1976. The use and abuse of astronomy in dating. *Creation Research Society Quarterly* 12: 201-10.
27. Courville, Donovan A. 1978. The chronology of the late kings of Egypt. *Catastrophism and Ancient History* I(1): 25-41.
28. Courville, Donovan A. 1981. Are the Peleset Philistines or Persians? *Catastrophism and Ancient History* III(2): 85-95.
29. Courville, Donovan A. 1981. Mesopotamian chronology from Abraham to the end of the first dynasty at Babylon. *Journal of Christian Reconstruction* VII(2):160-81.
30. Bimson, John J. 1978. Redating the exodus and conquest. Published by the *Journal for the Study of the Old Testament,* Sheffield.
31. Pensee (published from 1972 to 1974), *Kronos, Catastrophism and Ancient History*, and the *SIS Review* (published in Great Britain).
32. Velikovsky, Immanuel. 1977. Jericho. *Kronos* II(4):64-9.
33. Vaninger, Stan F. 1980. Archaeology and the conquest of Canaan. *Journal of Christian Reconstruction* VII(1):110-34.
34. Vaninger, Stan F. 1983/1984. Abraham to Hezekiah: an archaeological revision (in 2 parts). *Catastrophism and Ancient History* V(Pt. 2):69-85 and VI(Pt. I):5-18.
35. Courville, Donovan A. 1983. The Albredht/Glueck-Aharoni/Rothenberg Confrontation. Proceedings of the First Seminar of Catastrophism and Ancient History. Marvin Arnold Luckerman, editor.
36. See the series of exchanges between Bimson and Luckerman in the "Interaction" department of *Catastrophism and Ancient History* I (Pt. 2) and III (Pt. 1).
37. Emery, Walter. 1961. Archaic Egypt. Penguin, Baltimore, pp. 30-31, 38.
38. Compare this placement to Guenter who places the Tower of Babel incident at the transition between the Neolithic and Chalcolithic; Guenter, Ken. 1981. Implications of paleolithic stratigraphy for creationist models of pre-history. *Creation Research Society Quarterly* 18:168-69.
39. Albright, William F. 1971. The archaeology of Palestine. Peter Smith, Goucester, pp. 71-72.

A STATISTICAL ANALYSIS OF THE POST-FLOOD GAP POSSIBILITY

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Received 24 July 1984; Revised 9 January 1985

Abstract

An extensive statistical analysis of the post-Flood lifespans with various calibration models shows that it is possible to find statistical models that predict hundreds and possibly even thousands of years between patriarchs. However, if the interpolation and extrapolation performance of the calibration model plus the model's insensitivity to statistical outliers is considered, there are statistical calibration models using the natural logarithm of lifespan that show no gaps in the Genesis 11 genealogy.

Introduction

Evolutionary anthropologists contend that man in his present form has been in existence from one to two million years. This evolutionary thinking, however, seems to be in direct contradiction with the Bible. Henry Morris has noted this conflict in *Biblical Cosmology and Modern Science:*

> To explain a discrepancy between one million and two thousand years, for the time from the first man to the time of Abraham (about 2000 B.C. by secular chronology) in terms of genealogical gaps means that the average such gap between each pair of names in Genesis 5 and 11 is more than fifty thousand years! Each "gap" is therefore more than eight times as long as the entire period of recorded history.[1]

Recently, Richard Niessen countered this evolutionary thinking on genealogical gaps in Genesis 5 and 11 by presenting nine logical and mainly Biblical evidences for a tight chronology." A follow-up to the Biblical evidence for no gaps was provided in statistical evidence by William Seaver.[3] His statistical analysis of these Genesis lifespans showed that the pre-Flood lifespans were stable, that the post-Flood life spans fitted an asymptotic exponential decay curve which converged to the 70-80 year lifespan of Psalm 90:12, and that if there were gaps in the genealogies of Genesis 11 the gaps would have to "systematic, specific, nonrandom, and of the asymptotic exponential decay model form."[4] In addition to the Biblical and statistical evidence for no gaps, scientific research from other disciplines is also supporting the point of a tight chronology in Genesis 5 and 11. For instance, Humphreys' excellent work on the creation of earth's magnetic fields revealed that it would take approximately 6000 years for the magnetic fields to decay to their present

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strength if the current rate of decline was extrapolated back to Creation.[5] The weight of Biblical, statistical, and scientific evidence for a tight chronology in Genesis 5 and 11 is great, and thus the likelihood of gaps of any significant size are very small. Henry Morris does not deny the possibility that minor gaps could occur in the Genesis 11 genealogical list; but if they exist, the gaps must be relatively small and not thousands of years as proposed by evolutionists.[6,7]

The intention of this author is not to examine the Genesis 5 genealogy since the Biblical evidence from Genesis 4:25, 26 and Jude 11 allows for no gaps. Niessen's study on tight chronology in Genesis 5 and 11 is an excellent source for the theological arguments. However, the clearest possibility for a gap, according to Morris and Whitcomb, is in the genealogy of Genesis 11 between Eber and Peleg before the Tower of Babel where the lifespans dropped from 464 to 239 years respectively.[8] Recent statistical model methods developed for the calibration problem shall be used to find point and interval estimates for the generations between patriarchs (particularly between Peleg and previous patriarchs) that provide evidence of the statistical feasibility of a tight chronology for Genesis 11. Not only does this imply that any gaps would have to be minor but also that the Flood date of 2518 B.C. is a stable, safe estimate.

The Apparent Post-Flood Gap

Assuming consecutive generations, that is, no gaps in the Genesis 5 and 11 genealogies, the dates for the year of birth and lifespan are given in Table I.[9,10] A semilogarithmetic graph of the post-Flood lifespans versus the generations in Figure 1 as done by Dillow reveals the gap possibility between Eber and Peleg.[11,12] However, a graph of these same lifespans versus the patriarchs year of birth after Creation in Figure 2 with semilogarithmetic scale accents the apparent gap between Eber and Peleg to such an extent that two different models seem to be necessary to fit the post-Flood data: one before Peleg and one after him. Since the four patriarchs, Shem, Arpachshad, Shelah, and Eber, are insufficient data points to derive a statistical model, attention is focused on all the lifespans inclusive of Peleg down to Moses' contemporaries. With these ten observations, it is possible to derive statistical models which fit this post-Flood era and provide predictions of how many generations away Eber's lifespans are from Peleg. While point estimation of the generations or the gap is the primary concern, a statistical interval estimation procedure (where appropriate) will be used so that there is a measure of confidence about any perceived gap. As noticed in Table I, Peleg's generation will be the base, and the generations from Peleg to Joseph are assumed to be consecutive in light of Seaver's statistical chronological work on the post-Flood data.[13]

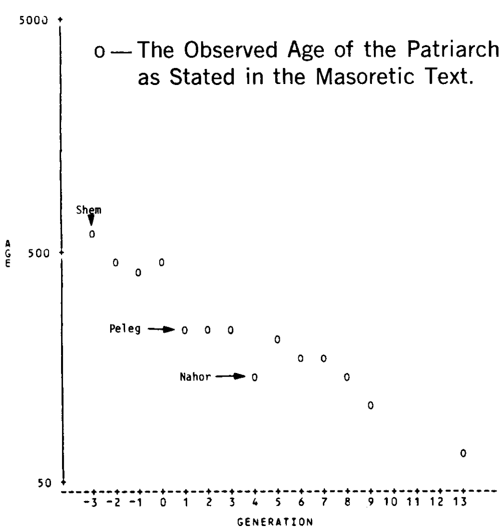


Figure 1. Semilogarithmetic Graph of Lifespans Versus Generation of Patriarch.

Statistical Calibration Models

Most statistical regression models involving the prediction of a point require determining the value of Y corresponding to a given X. For example, to calibrate a thermocouple, we assume that the temperature reading given by the thermocouple is a linear function of the actual temperature with an error term ϵ_i such that the observed temperature $= \beta_0 + \beta_1$ (actual temperature) $+ \epsilon_i$ or

$$Y_i = \beta_0 + \beta_1 X_i + \epsilon_i, \qquad (1)$$

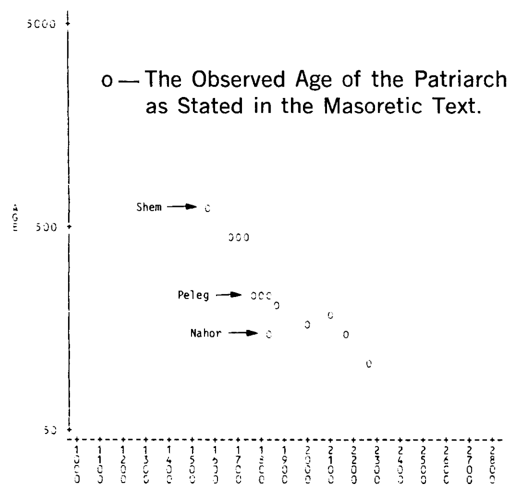


Figure 2. Semilogarithmetic Graph of Lifespans Versus Year of Birth after Creation.

where β_0 and β_1 are unknown parameters. The calibration problem is concerned with measuring the actual temperature X* from the observed temperature Y* given the data $(Y_1, X_1), (Y_2, X_2) \ldots, (Y_n, X_n)$ which is used to derive the estimating equation,

$$\hat{Y}_i = b_0 + b_1 X_i, \qquad (2)$$

where b_0 and b_1 are estimates of β_0 and β_1 respectively. For the post-Flood data, Y_i equals the lifespan which is completely known, and X_i equals the generation of the patriarch which is assumed partially known. Thus, the prime concern in calibration analysis is point estimation of the X values from the known Y values.

There are several competing point estimators of X, each with advantages and disadvantages. There is the classical estimator,

$$X_c^* = (Y^* - b_0)/b_1 \qquad (3)$$

Table I. Selected Post-Flood Lifespans

Patriarch	Year of Birth After Creation	Year of Birth Before Christ, B.C.	Life-Span†	Age at Birth of Son	Generations from Peleg
Noah	1056	3118	950	502	?††
Shem	1558	2616	600	100	?
Arpachshad	1658	2516	438	35	?
Shelah	1693	2481	433	30	?
Eber	1723	2451	464	34	?
Peleg	1757	2417	239	30	1
Reu	1787	2387	239	32	2
Serug	1819	2355	230	30	3
Nahor	1849	2325	148	29	4
Terah	1878	2296	205	130	5
Abraham	2008	2166	175	100	6
Isaac	2108	2066	180	60	7
Jacob	2168	2006	147	91	8
Joseph	2259	1915	110	?	9
Moses' Contemporaries	—	—	70	—	13

†Ages are taken from the Masoretic Text.
††If the generations are consecutive, then Noah through Eber's generations would be -4, -3, -2, -1, and 0 respectively.

where b_0 and b_1 are the least square solutions to β_0 and β_1 in (1) above based upon n observations. With this classical estimator, interval estimates for X* (the number of generations) can be constructed.[14,15] Lwin and Maritz have noted that the classical estimation model does best when estimation is confined to extrapolation (the extremities of the range and outside of the calibration range) which is the need for this gap analysis.[16] In addition, with the classical predictor model it is possible to compare the fitted values $\hat{Y}_i$ and the observed values Y_i (called residuals, $e_i = Y_i - \hat{Y}_i$) to flag any unusual observations (called outliers) that could hinder the model from accurate prediction. Figure 2 definitely seems to indicate that Nahor's lifespan was shorter than expected and thus a possible statistical outlier. As noted by Belsley, Kuh, and Welsch and other statisticians, there are numerous outlier diagnostics for the classical linear regression model.[17-19]

A second possible estimator where generation is regressed against lifespan is the inverse estimator

$$X_i = \beta'_0 + \beta'_1 Y_i + \epsilon'_i \tag{4}$$

where β'_0 and β'_1 are the parameter values of the population and ϵ'_i is again some measurement of error. The sample inverse estimation model is shown as follows:

$$X^*_{inv} = b'_0 + b'_1 Y^* . \tag{5}$$

Intuitively, this inverse estimator seems viable. However, the inverse point estimator is only superior to the classical estimator when X* lies in a small interval about X_0, i.e., estimation is restricted to the interior of the calibration range.[20,21] Thus, it should be expected that this estimator will do well for Peleg through Moses' contemporaries and not well outside of this range.

A third feasible estimator of generation X* is a nonparametric regression approach based on the median of pairwise slopes.[22] This basic regression model (equation (6) below), developed by Thiel,

$$Y^* = b''_0 - \text{Median}\,\{b''_1\}\, X^*_{np} \tag{6}$$

does not allow for interval estimates for an individual observation; but it is not affected by statistical outliers, such as Nahor. Equation (6) can be converted to a nonparametric calibration model as shown below:

$$X^*_{np} = (Y^* - b''_0)/\text{Median}\,\{b''_1\}. \tag{7}$$

Finally, there is the non-linear predictor of Schwenke and Milliken but confidence intervals for small samples are not exact, and this procedure is totally valid only when Y and X can both be taken as random variables, a requirement also necessary for the inverse estimator.[23] Thus, attention shall focus only on the classical, the inverse, and the nonparametric models.

If the post-Flood data from Peleg to Moses' contemporaries do support the hypothesis $|\beta_1| > 0$, then the calibration model in general is appropriate.[24] The more significant the relation between Y and X or ln Y and X, the better the calibration model will perform.

Point Estimation of the Generation Gap by the Lifespan Models

Using only the lifespans and not the natural logarithm of lifespan [ln(lifespan) or ln Y] from Peleg to Moses' contemporaries, Table II shows the equation results for the classical, the inverse, the nonparametric, and the jackknife model (which Duncan and others have noted as more insensitive to one outlier in the data).[25,26] The intercepts, 258.114, 271 and 258.3, and the slopes, -14.45, -15.00, and -14.51 respectively for the classical, the inverse, and the jackknife models are not that different, respectively. Assuming consecutive generations, all four lifespan models are 11 to 14 generations from Eber at X = 0, creating a possible gap of 12 to 15 generations between Eber and Peleg. With the median begetting age of Table I being 34 years and ignoring Noah and Shem who were born before the Flood, we could be dealing with a gap of at least 416 years ([l + 14.25] x 34) between Eber and Peleg. There are also large generation prediction gaps for the other three pre-Peleg Patriarchs as shown in Table II. For instance, Shem is off by at least 16 generations (-3-(-19.23)) to almost 21 generations

Table II. Comparative Analysis of Gap Possibilities by Four Lifespan Models.

Model	Classical	Inverse	Nonparametric	Jackknife
Equation	$X^*_i = \frac{(Y_i - 258.114)}{(-14.45)}$	$X^*_i = 16.049 - .0588Y_i$	$X^*_i = \frac{(Y_i - 271)}{(-15.00)}$	$X^*_i = \frac{(Y_i - 258.3)}{(-14.51)}$
Sum of Squares Interpolation (SS_{inter})	20.764	17.671	23.617	20.615
Sum of Squares Extrapolation (SS_{extra})	862.311	519.923	703.379	853.001
General Predictions† Prior to Peleg				
Shem (−3)	−23.66	−19.23	−21.93	−23.55
Arpachshad (−2)	−12.45	−9.71	−11.13	−12.38
Shelah (−1)	−12.10	−9.41	−10.80	−12.04
Eber (0)	−14.25	−11.23	−12.87	−14.18

†Assuming consecutive generations, the expected generations away from Peleg are indicated in parentheses. The SS_{extra} are computed from these expected values and the predicted values for each model.

(-3-(-23.77)). Furthermore, all four lifespan models have a very low sum of squares $\left(\sum_{i=1}^{n} (X_i - X^*)^2\right)$ for interpolation (with the inverse model the lowest at 17.671) but extremely large sum of squares for extrapolation. These findings are excellent fuel for the evolutionist's argument that there are gaps in the genealogies or to the idea that there is one statistical model for the pre-Peleg patriarchs and another for Peleg and those that follow.

In addition to examining the sum of squares for the X (the generation) to measure the fit of the calibration model, further insight into the adequacy of a statistical model is gained by comparing the observed values of the lifespan (Y_i) versus the predicted values for lifespan ($\hat{Y}_i$). These differences, $e_i = Y_i - \hat{Y}_i$, are called residuals. Extremely large residuals, large studentized residuals, large studentized residuals with the i^{th} observation deleted, large diagonal elements of the hat matrix, large changes in fit at some data point i standardized by the standard error of the fit with the i^{th} point omitted, plus other outlier diagnostics can be used to flag extreme observations that have diverse but drastic effects on linear models.[27] With a Pearson correlation of .9218 (significant at a probability less than .0001) between lifespan and generation for the classical and the inverse models, it is tempting to conclude that the model is appropriate. However, Nahor is flagged as a outlier by numerous statistical diagnostics but particularly by a studentized residual with the i^{th} observation deleted of -4.28, significant at a probability less than .005 . Removal of Nahor from the classical or inverse lifespan models does not change the generation predictability appreciably even though the Pearson correlation does increase to .9783. In fact, with the removal of Nahor, various outlier diagnostics suggested by Hoaglin and Welsch flag Peleg, Joseph, and Moses' contemporaries as suspect influential observations.[28]

While the evolutionist who desires to show gaps in the Genesis 11 genealogies to support his beliefs or the researcher who may even want to push back the Flood date further than 2518 B.C. with partial gaps to accommodate various archaeological suppositions may embrace any of these four lifespan models to validate his stance, the poor performance of these four calibration models in extrapolation, the outliers in the models, and the previous research of Dillow and Seaver all suggest that there must be a better statistical and Biblical model. This model, if it exists, should do well in interpolation and extrapolation for generation, should be minimally affected by outliers, and should not differ drastically from previous research on these patriarch ages. The natural logarithm model [ln(lifespan) or ln (Y)] is such a possibility.

Point Estimation of the Generation Gap by the Natural Logarithm Models

Dillow used the natural logarithm model

$$\ln Y = \ln b_0 + b_1 X \tag{8}$$

to describe the non-linear or exponential decay relationship between generation and lifespan over the patriarchs from Noah to Moses' contemporaries.[29] Seaver's non-linear model, the asymptotic exponential decay, not only described the relationship between lifespan and generation better over the observations from Shem to Moses' contemporaries but also predicted well outside of the data's range.[30] There are non-linear calibration models as mentioned earlier, but such sophistication is statistical overkill. The easiest approach is to take the models in equations (2)-(7) and replace Y with ln(Y) producing the following three new calibration models.

$$X^*_c = (\ln Y^* - \ln b_0)/b_1 \tag{9}$$

$$X^*_{inv} = b_0^1 + b_1^1 \ln Y^* \tag{10}$$

$$X^*_{np} = (\ln Y^* - b_0'')/\text{Median}\,\{b_1''\}. \tag{11}$$

Of course, these calibration models based on natural logarithms could be converted to an exponential decay curve of the form,

$$\hat{Y}_i = b_0 e^{-b_1 X_i} \tag{12}$$

This conversion is not necessary since the concern is the prediction of X, the generation.

Still assuming consecutive generations but using the ln(lifespan) or ln(Y) calibration models, the sum of squares interpolation in Table III are slightly less than those for the basic lifespan model (as shown in Table II) with greater improvements for the nonparametric

Table III. Comparative Analysis of Gap Possibilities by Four Natural Logarithm Models

Model	Classical	Inverse	Nonparametric	Jackknife
Equation	$X^*_i = \frac{(\ln Y_i - 5.6780)}{(-.0995)}$	$X^*_i = 49.4525 - 8.5579 \ln Y_i$	$X^*_i = \frac{(\ln Y_i - 5.9342)}{(-.1309)}$	$X^*_i = \frac{(\ln Y_i - 5.7018)}{(-.1064)}$
Sum of Squares Interpolation (SS_{inter})	20.473	17.443	21.844	18.628
Sum of Squares Extrapolation (SS_{extra})	52.284	17.402	3.504	38.033
General Predictions† Prior to Peleg				
Shem (−3)	−7.22	−5.29	−3.53	−6.53
Arpachshad (−2)	−4.06	−2.50	−1.13	−3.58
Shelah (−1)	−3.95	−2.50	−1.04	−3.47
Eber (0)	−4.64	−3.09	−1.57	−4.12

†Assuming consecutive generations, the expected generations away from Peleg are indicated in parentheses. The SS_{extra} are computed from these expected values and the predicted values from each model.

(23.617 to 21.844 SS_{inter}) and the jackknife models (20.615 to 18.28 SS_{inter}). This finding is extremely significant in that it points out that all of the Y and ln(Y) models have similar descriptive ability for the data of Peleg to Moses' contemporaries and that the natural logarithm transformation did not affect interpolation results. Further support of this point is provided by a similar Pearson correlation for the ln(Y) model [classical and inverse only] of .9229, significant also at $\alpha <$ .0001. However, for the four pre-Peleg patriarchs there is an astronomical decrease in the sum of squares extrapolation: from 862.311 to 52.284 for the classical model, from 519.923 to 17.402 for the inverse model, from 703.379 to 3.504 for the nonparametric model, and lastly from 853.001 to 38.003 for the jackknife model as shown in Tables II and III. In light of these extrapolation results and the specific generation difference in Table IV, the nonparametric calibration model based on ln(Y) is by far the best point estimator of patriarch generations. This particular nonparametric model misses Eber by only 1.57 generations and is easily within one generation of Shem, Arpachshad, and Shelah (see Table IV). None of the other three ln(Y) calibration models predict large gaps in the generation; but there are consistent gaps of 2-4 generations for Shem, Eber, Nahor and Isaac.

Table IV. Generation Differences for the Classical, Inverse, Nonparametric, and Jackknife Calibration Models

Patriarch	Classical	Inverse	Non-parametric	Jack-knife
Shem	4.22	2.29	.53	3.53
Arpachshad	2.06	.60	.87	1.58
Shelah	2.95	1.50	.04	2.47
Eber	4.64	3.09	1.57	4.12
Peleg	-1.03	-1.59	-2.50	-1.12
Reu	-.03	-.59	1.50	-.12
Serug	.59	.09	.79	.52
Nahor	-2.84	-2.69	-3.16	-2.62
Terah	1.43	1.10	.33	1.04
Abraham	.84	.75	.12	.95
Isaac	2.13	1.99	1.34	2.22
Jacob	1.09	1.25	.79	1.31
Joseph	-.82	-.23	-.42	-.41
Moses' Contemporaries	-1.36	-.09	-.12	-.66

These findings give extreme credence to the faith of the Creationist that there cannot be large gaps of thousands of years in the Genesis 11 genealogy but no more than around a hundred years. However, the ln(Y) nonparametric model is even more significant in that there is a statistical model that can be fitted to the untouched Genesis 11 lifespans without compromising the Biblical truth of consecutive generations noted by Niessen.[31]

Additional Evidence for the ln(Y) Nonparametric Calibration Model

In light of statistical theory mentioned earlier, a natural question is why does the ln(Y) inverse calibration model do better than the ln(Y) classical model in extrapolation? The reason for this discrepancy is the greater outlier tendencies in the variable ln(Y) than in the variable generation. This is more obvious when Nahor, a statistical outlier having the studentized residual with the i^{th} observation deleted of 2.4 which is significant at a level of significance of .025 (but not as significant as in the classical lifespan model), is deleted from the data. The equations for the classical and inverse calibration models with Nahor omitted are shown below:

$$X^\dagger_i = (\ln(Y^\dagger_i) - 5.7392)/(-.1045) \tag{13}$$

and

$$X^\dagger_i = 50.9177 - 8.7861 \ln(Y^\dagger_i). \tag{14}$$

While there are slight coefficient changes in these models compared to the full data equivalents in Table III, the biggest changes occur in the SS_{inter} and SS_{extra}. The SS_{extra} for the classical model reduces drastically from 52.284 to 31.840 but there is only a miniscule change from 17.402 to 16.712 for the inverse model. The inverse model shows marked improvement from 16.443 to 9.351 for SS_{Inter} while the classical changes slightly from 20.473 to 19.773. The improvements for the inverse model were thus over the interpolation range and conversely were for the classical model over the extrapolation range, which is to be expected in light of the outliers and statistical theory.

Additional insight into the impact of observations such as Nahor, Peleg, Isaac, and Moses' contemporaries on the ln(Y) classical model can be gained by examining the recursive residuals. Recursive residuals are independently and identically distributed and, unlike ordinary residuals, do not have the deficiencies of the data in one part being spread over all the residuals.[32] For instance, in studentized residuals with the i^{th} observation deleted (such as Nahor), there is an isolated look at whether one observation is a statistical outlier. It is not uncommon for one statistical outlier to mask others in the same data set, and recursive residuals flag this problem. Basically, for this Genesis data set of 10 points, discard the first patriarch, Peleg, and fit the model to the remaining nine points. The first recursive residual is then defined as the standardized residual of the first observation. Next Peleg and Reu are discarded, and the model is fitted to the remaining eight observations. The second recursive residual is then computed. The process is repeated down to the last two observations (Joseph and Moses' contemporaries) since at least two points are needed for the fitting of a two-parameter model. The recursive residuals are given in Table V and a normal probability plot of these residuals is in Figure 3. According to Galpin and Hawkins, Nahor would definitely be an indicative of other possible outliers such as Peleg (-.1216) and Isaac (-.0937).[33]

A significant by-product of the recursive residual analysis is a recursive calibration model with sum of squares extrapolation computed in Table V. Remembering that the SS_{extra} are only computed for the patriarchs Shem through Eber, it is interesting to note the continual improvement in the SS_{extra} as successive observations are deleted. In fact, the recursive calibration model after omission of Peleg, Reu, Serug, and Nahor

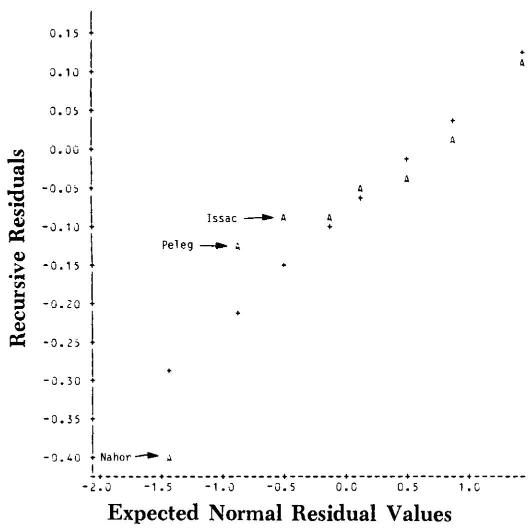
$$X^* = (\ln Y^* - 6.0464)/(-.1387) \tag{15}$$

is almost identical to that for the nonparametric ln(Y) model in Table III (the best calibration model using all the data),

$$X^* = (\ln Y - 5.9342)/(-.1309). \tag{16}$$

This recursive calibration model has SS_{cxtra} = 4.39 whereas the nonparametric ln(Y) model had SS_{extra} = 3.504. Also, the recursive calibration model for Jacob, Joseph, and Moses'contemporaries is almost identical to that of the nonparametric ln(Y) model.

While interval estimates for an individual observation are not possible for the nonparametric model nor for the inverse model since generation is not a random variable, it is possible to construct such an interval estimate for the classical calibration mode1.[34] Since the recursive classical ln(Y) model for Terah is practically identical to the nonparametric ln(Y) calibration model and is highly significant (a Pearson correlation of .9813, significant even at α = .005), an interval estimate for the generation of the patriarch can be computed for Shem through Eber according to the following formulas, where



A — the actual recursive residual for the patriarchs (Table V)
If +\$ are connected with a straight line, recursive residuals that deviate markedly from this line may be considered outliers.

Figure 3. Normal Probability Plot of Recursive Residuals.

$$g = ts\left[(Y^* - \bar{Y})^2/\Sigma(X_i - \bar{X})^2 + b_1^2(1 + 1/n) - [t^2s^2/\Sigma(X_i - \bar{X})^2][1 + 1/n]\right]^{1/2} \tag{17}$$

and

$$\begin{matrix} X_{upper} \\ X_{lower} \end{matrix} = \bar{X} \pm \left[b_1(Y_0 - \bar{Y}) + g\right] / \left[b_1^2 - t^2s^2/\Sigma(X_i - \bar{X})^2\right]. \tag{18}$$

These 95 percent confidence interval estimates, which are not symmetric about the point estimate for generation, are shown in Table VI below,

The largest difference from the assumed consecutive generation and the upper interval estimate is no more than 4.57 generations for Eber and no less than 2.02 generations [-2-(4.02)] for Arpachshad. Assuming the median begetting age of 34 years as done earlier, there could be gaps of not more than 70-170 years at the maximum for the interval estimate analysis.

Table V. Recursive Residual Analysis for the Classical ln(Lifespan) Model.

Observation	Patriarch	Lifespan	Recursive Calibration Equation with Prior Observations Deleted	Recursive Residuals	Sum of Squares Extrapolation
1	Peleg	239	$(\ln Y^* - 5.6780)/(-.0995)$	−.1216	52.31
2	Reu	239	$(\ln Y^* - 5.7269)/(-.1054)$	−.0478	33.59
3	Serug	230	$(\ln Y^* - 5.7505)/(-.1082)$	+.0148	26.81
4	Nahor	148	$(\ln Y^* - 5.7414)/(-.1072)$	−.3949	29.24
5	Terah	205	$(\ln Y^* - 6.0464)/(-.1387)$	−.0382	4.39
6	Abraham	175	$(\ln Y^* - 6.0840)/(-.1424)$	−.0860	6.04
7	Isaac	180	$(\ln Y^* - 6.1942)/(-.1526)$	−.0937	13.67
8	Jacob	197	$(\ln Y^* - 6.0292)/(-.1383)$	+.1092	3.86
9	Joseph	110	$(\ln Y^* - 5.7174)/(-.1130)$	————	29.09
10	Moses' Contemporaries	70	————	————	———

Table VI. Ninety-five Percent Confident Estimates for the Individual Pre-Peleg Patriarchs*

Patriarch	Consecutive Generation	Point Estimate of Generation	Lower Interval Estimate	Upper Interval Estimate
Shem	- 3	-2.53	.28	-7.01
Arpachshad	- 0	-.26	2.18	-4.02
Shelah	- 1	-.18	2.25	-3.91
Eber	0	-.67	1.83	-4.57

*These are not simultaneous confidence interval estimates but only individual interval estimates.[35]

Validation of the Model

To the non-statistician it would seem as if there has been model manipulation in locating a statistical model that fits the generation and ln(age) relationship. However, the discussion thus far has focused on checking the adequacy of the model and to a large extent on model validation. According to Montgomery and Peck, the essence of model validation is determining "if the model will function successfully in its intended operating environment."[36] This validation process involves testing the predictive performance of the model in the interpolation and extrapolation modes, examining signs and magnitudes of the model coefficients, comparing the model predictions and coefficients with physical theory, and studying the stability of the model coefficients as a result of outliers or diverse correlation structures.[37] Much of this has already been done. Considering the extrapolation mode and the stability of the coefficients, the nonparametric calibration In (age) model (equation 16) which is based on the actual data without any omissions and which is outlier resistant seems to be the better post-Flood model. In terms of interpolation, the inverse and classical calibration models using ln(age) (equations 13 and 14) fare slightly better.

To complete the model validation process, there are a few possible statistical approaches.[38] First, the collection of fresh data with which to investigate the model's predictive performance is a possibility, but with historical data as in Genesis this is not feasible. Seaver, in his study of the Genesis lifespans, did show how the asymptotic exponential decay curve provided excellent estimates for today's lifespan.[39] A second choice for validation is data splitting. For a time sequenced data set, the observations would be split into an estimation data set and a prediction data set; but for the Genesis data there are not enough observations for such an approach according to Snee.[40] However, another version of data splitting which essentially takes n observations and splits these into n subsamples of size one is a simplistic validation procedure. The regression model is then fitted to the remaining n - 1 observations and the resulting equation is used to predict the withheld observation, y_i. If the predicted value with the i^{th} observation deleted is noted $\hat{y}_{(i)}$, then the prediction error for the point i is

$$e_{(i)} = y_i - \hat{y}_{(i)} \tag{19}$$

and the prediction error for all points is the sum of squares for the n deleted residuals over the interpolation range that is, $\Sigma e^2_{(i)}$.[41, 42] This sum of squares is called the PRESS statistic and can be found by either formula below:

$$PRESS = \sum_{i=1}^{n} \left(y_i - \hat{y}_{(i)}\right)^2 \tag{20}$$

or

$$PRESS = \sum_{i=1}^{n} \left(\frac{e_i}{1-h_{ii}}\right)^2 \tag{21}$$

The formula in equation (21) makes it easy to see that the PRESS statistic is just a weighted sum of squares of the residuals, where the weights are related to the outlier tendencies of the observation (h_{ii}).[43]

Performing this kind of analysis on the inverse and classical calibration models using ln(age) as shown in Table VII provides a way to validate the overall predictive performance and to flag observations that degrade the predictive performance of the model. While the original inverse and classical models explained 85 percent of the variability in the response variable (R^2 = .8517), an approximate coefficient of determination for prediction (called R^2_{pred}) can be calculated for each model from the PRESS statistic information as follows:

$$R^2_{pred} = 1\text{-PRESS/sum of squares for response variable} \tag{22}$$

From Table VII the inverse model explains about 80 percent of the variability in predicting new observations. The drop in explainability from 85 to 80 percent is due to the high prediction error squared for Nahor primarily (9.072), followed slightly by Isaac and Peleg. For the classical ln(age) model, the explainability drops from 85 to 75 percent and is again primarily due to Nahor and Isaac (.10505 and .05678 respectively) but also to Moses'contemporaries at .08746.

The bottom line of this type of validation is that the ln(age) calibration models work well in interpolation. Again certain patriarchs are highlighted as influential observations for these models signifying even more that the outlier resistant nonparametric calibration model is a better choice for explaining the post-Flood data of Genesis.

Conclusions

This statistical analysis of gaps in the post-Flood genealogy of Genesis 11 with calibration models, which consider lifespan as a random variable and generation as fixed, has several important conclusions and implications. First, the Genesis 11 lifespan data is very complicated because of the statistical outliers: Nahor who died before his time, Peleg and Reu who lived to be of the same age in an era of declining lifespan, Isaac who lived longer than expected at 180 years, and Moses' contemporaries who lived to 70-80 years according to Psalm 90:12. With at least 40 percent (4 out of 10) of these data having outlier tendencies, only recent statistical outlier diagnostics have enabled the researcher to flag these unusual observations and to examine their diverse impact on the mathematical model for longevity and on the creationist view of consecutive generations in Genesis 11.

Secondly, it is possible to choose a statistical model based on lifespans which will predict large gaps of hundreds of years or more between the pre-Peleg patriarchs, which the evolutionists might extend to thousands of years or more to maintain his position on the age of the earth. However, when sound statistical reasoning considers the interpolation and extrapolation

Table VII. One by One Data Splitting Validation of the Inverse and Classical ln(Age) Calibration Models.

		Inverse Model			Classical Model		
Generation	ln(Age)	Residual e_i	h_{ii}	Square of Prediction Error $[e_i/(1-h_{ii})]^2$	Residual e_i	h_{ii}	Square of Prediction Error $[e_i/(1-h_{ii})]^2$
1	5.476	−1.585	.203	3.957	−.102	.296	.02100
2	5.476	−.585	.203	.539	−.003	.223	.00001
3	5.438	.086	.183	.011	.059	.167	.00494
4	4.997	−2.687	.108	9.072	−.283	.128	.10505
5	5.323	1.101	.136	1.624	.143	.105	.02539
6	5.165	.747	.103	.694	.084	.100	.00869
7	5.193	1.988	.106	4.947	.212	.112	.05678
8	4.990	1.255	.109	1.984	.109	.141	.01597
9	4.700	−.226	.217	.083	−.082	.187	.10115
13	4.248	−.094	.631	.065	−.136	.541	.08746
Press				22.976			.33543
$R^2_{prediction}$	$1 - 22.976/117.60 = .8046$				$1 - .33543/1.36756 = .7547$		

quality of the calibration model plus the impact of statistical outliers, the existence of gaps in the Genesis 11 genealogy is not a tenable position. It is an encouragement to the Creationist to know that there exists a statistical model which shows no gaps between Eber and Peleg or between any of the other patriarchs and which reveals that the differences in ages in Genesis 11 are statistically possible.

Thirdly, these findings of no gaps using only part of the post-Flood data from Peleg to Moses'contemporaries plus the earlier research of Dillow and then Seaver who used all the data of Genesis 11 gives even further confirmation that any gaps would have to be systematic, specific and nonrandom and of the exponential decay, more probably, of the asymptotic exponential decay form. The excellent performance of the nonparametric ln(lifespan) calibration model and the parametric ln(lifespan) recursive model in extrapolation and interpolation gives tremendous confidence in a Flood date of 2518 B.C. and a Creation date of 4174 B.C. and shows the scientific and statistical reliability of the Scriptures.

Finally, from a statistician's viewpoint, there is a simplistic beauty in a series of numbers that is easy to acknowledge as randomness and nonmeaningful and thus, miss the Creator behind them. However, close examination of the complexity of the lifespans in Genesis 11 in this research causes one to stand in awe of God's wisdom, God's character, and His revelation to man.

References

1. Morris, Henry M. 1970. Biblical cosmology and modern science. Craig Press, Nutley, New Jersey, p. 67.
2. Niessen, Richard. 1982. A Biblical approach to dating the earth: a case for the use of Genesis 5 and 11 as exact chronology. *Creation Research Society Quarterly* 19:60-66.
3. Seaver, William L. 1983. A statistical analysis of the Genesis life-spans. *Creation Research Society Quarterly* 20: 80-87.
4. *Ibid.*, p. 87.
5. Humphreys, D. Russell. 1983. The creation of the earth's magnetic field. *Creation Research Society Quarterly* 20: 89-94.
6. Morris. *Op. cit.*, pp. 67, 68.
7. Morris, Henry M., and John C. Whitcomb. 1961. The Genesis Flood. Presbyterian and Reformed, Philadelphia, pp. 474-89.
8. *Ibid.*, p. 487.
9. Merrill, Eugene H. 1980. Fixed dates in patriarchal chronology. *Bibliotheca Sacra* 137 (July-September):241-51.
10. Niessen. Op. *cit.*, p. 62.
11. Dillow, Joseph C. 1978. The canopy and ancient longevity. *Creation Research Society Quarterly* 15:27-34.
12. Dillow, Joseph C. 1981. The waters above: earth's pre-Flood vapor canopy. Moody Press, Chicago, pp. 157-64.
13. Seaver. *Op. cit.*
14. Montgomery, Douglas C. and Elizabeth A. Peck. 1982. Introduction to linear regression analysis. John Wiley and Sons, Inc. New York, pp. 400-405.
15. Seber, G. A. F. 1977. Linear regression analysis. John Wiley and Sons, Inc., New York, pp. 187-90.
16. Lwin, T. and J. S. Maritz. 1982. An analysis of the linear calibration controversy from the perspective of compound estimation. *Technometrics* 24(3):235-42.
17. Belsley, David A., Edwin Kuh and Roy E. Welsch. 1980. Regression diagnostics. John Wiley and Sons, Inc., New York.
18. Hoaglin, David C. and Roy E. Welsch. 1978. The hat matrix in regression and ANOVA. *The American Statistician* 32(1):17-22.
19. Cook. Dennis E. 1977. Detection of influential observation in linear regression. *Technometrics* 19(1):15-18.
20. Lwin and Maritz. *Op. cit.*, pp. 239-40.
21. Montgomery and Peck. Op. *cit.*, pp. 402-03.
22. Hollander, Myles and Douglas A. Wolfe. 1973. Nonparametric statistical methods. John Wiley and Sons, Inc., New York, pp. 200-08.
23. Schwenke, James R. and George A. Milliken. 1983. On the calibration problem extended to non-linear models. *1983 Proceedings of the Biopharmaceutical Section of the American Statistical Association*, pp. 68-72.
24. Lwin and Maritz. *Op. cit.*, p. 239.
25. Duncan, George T. 1978. An empirical study of jackknife-constructed confidence regions in nonlinear regression. *Technometrics* 20(2):123-29.
26. Fox, Terry, David Hinkley and Kinley Larmtz. 1980. Jackknife in nonlinear regression. *Technometrics* 22(1): 29-33.
27. Hoaglin and Welsch. *Op. cit.*, pp. 17-21.
28. *Ibid.*
29. Dillow. *Op. cit.*, pp. 27-28.
30. Seaver. *Op. cit.*, pp. 82-85.
31. Niessen. *Op. cit.*, pp. 62-66.
32. Galpin, Jacquelin S. and Douglas M. Hawkins. 1984. The use of recursive residuals in checking model fit in linear regression. *The American Statistician* 38(2):94-105.
33. Galpin and Hawkins suggest that the pattern in Figure 3 may be due to outliers in the base points, such as Jacob, Joseph and Moses' contemporaries. Recomputation of the recursive residuals omitting first Moses' contemporaries then Joseph, etc., revealed normality of the recursive residuals with Nahor and Moses' contemporaries as outliers.
34. Draper, Norman and Harry Smith. 1981. Applied regression analysis, second edition. John Wiley and Sons, Inc., New York, pp. 47-51.
35. Montgomery and Peck. *Op. cit.*, pp. 389-400.
36. *Ibid.*, pp. 424, 425.
37. Snee, R. D. 1977. Validation of regression models: meth-

ods and examples. *Technometrics* 19(4):415-28.
38. Draper and Smith. *Op. cit.*, pp. 419-21.
Seaver. *Op. cit.*, p. 85.
40. Snee. *Op. cit.*, p. 422.
41. Allen, D. M. 1971. The prediction sum of squares as a criterion for selecting prediction variables. Technical Report No. 23, Department of Statistics, University of Kentucky.
42. Allen, D. M. 1974. The relationship between variable selection and data augmentation and a method for prediction. *Technometrics* 16(1):125-27.
43. Montgomery and Peck. *Op. cit.*, pp. 430-32.

PANORAMA OF SCIENCE

More on Growth of a Population

Creationists, at least those of the young-Earth variety, are very much interested in the growth of populations, in order to see how the population increased so quickly after the Flood. An example from Canadian history may be of some interest. In a book on Canadian history it is stated:

> In the conquered province of Quebec, the people multiplied with astonishing celerity. In 1760, their numbers were approximately 60,000, and in 1790, 160,000, an increase in one generation of about 166 percent, about five per cent annually. The birth rate after the conquest seems to have been higher than before it; in 1770 it had reached the astronomical figure of 65 per 1000. After all, there was land and food for all . . .[1]

The conquest was the British conquest of Canada in 1759 and 1760. Later the book states: ". . . there is some evidence (from the census) that the death rate was no higher in Upper Canada (now Ontario) in 1851 than it is in Ontario today . . ," and a little later:

> The statement made above, that the death rate in Upper Canada in 1851 may have been no higher than it is today may seem surprising, given our modern advantages, but the usual impression of the period as one of enormous infant mortality, epidemic disease, short lives and numerous deaths may need some revision. Certain causes of death carried off large numbers, but others fewer than today. Thus while 20 percent of all deaths were returned as from contagious diseases, there were only fifty deaths reported in the whole province from cancer.[2]

Editor's Note: One of the referees asked if the effects of immigration was included in the population growth. Harold's answer is as follows:

> The increase mentioned (More on the Growth of a Population) was wholly or mostly due to births. After 1759 there would have been very little immigration for quite a few years.

References

1. Lower, A. R. M. 1958. Canadians in the making. Longmans, Green and Company, Toronto, p. 113.
2. *Ibid.*, p. 192.

Contributed by Harold L. Armstrong

On the Nature of the Grains of Wind-Blown Sand

It is often taken for granted that grains of wind-blown sand, such as that found in a desert, should be more rounded than those on a beach. But a study, a few years ago, in the Simpson Desert, Australia, showed that the grains there are quite angu1ar.[1]

This may be of interest to Creationists because, while such deposits as loess, or the sand which went to form sandstone, are often supposed to have been deposited by the wind, the Flood would seem to have been a very likely agent. The study cited here would seem to show that it is hard to decide one way or the other by the shape of the grains.

There is another possible clue, however, which seems to have been little noticed. One might expect wind-blown sand often to contain vegetable material, such as tumbleweed, bits of brushwood, etc. Such debris is common in many sand dunes. And if the sand remained or hardened, the debris would remain as fossils.

When the sand was deposited by water, on the other hand, such debris would be floated away. As far as I can learn, fossilized debris is not common in sandstone. So this may be evidence that the sand was deposited by water; and what better opportunity has there been for such deposition than during the Flood?

Reference

1. Folk, Robert L. 1978. Angularity and silica coatings of Simpson Desert sand grains, Northern Territory, Australia. *Journal* of *Sedimentary Petrology* 48:611-24.

Contributed by Harold L. Armstrong

LETTERS TO THE EDITOR

Genesis 1

Frequently a question returns to me, does Genesis 1 refer to the entire Universe, or only to our Solar System? I am hoping you will place the following discussion in your "Letters to the Editor," where others can constructively criticize it. There are several verses in the Bible that bear on this problem.

We may recall that the Hebrew word *shamayim,* heaven(s), appears in Genesis 1:1. It is an unusual plural form, serving like the English word "sheep," and how it is used in the sentence will determine whether it shall be considered singular or plural. In Genesis 18 it is translated "firmament." According to the KJV translators, the verse should read "In the beginning God created the heaven and the earth."

Actually the word "heaven(s)" is of little help in clarifying just how much was created "in the beginning." To Bible writers "heaven(s)" was everything above their heads, and "earth" was everything under their feet. The Bible recognizes three heavens: (1) 1st heaven, atmospheric, Genesis 1:6-8; (2) 2nd heaven, starry, Genesis 15:5; and (3) 3rd heaven, Paradise where God dwells, II Corinthians 12:2.

More helpful in our problem of what was included in the work recorded in Genesis 1:1 are the words of Christ (Matthew 19:4) "Have ye not read that he which made them at the beginning made them male and female . . . ?" Other versions read: RSV, NEB "Made them from the beginning"; NASB "he who created them from the beginning"; Mark 10:6, NEB "in the beginning, at creation, God made them male and female." It thus appears that in the same great event "in the beginning," the earth and the heaven(s) and