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The Neolithic Demographic Transition in Mesoamerica

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The Neolithic demographic transition in Mesoamerica was a gradual process that unfolded over most of the Formative period (1800 BC–AD 200). An analysis of published records of over 6,700 pre-Hispanic burials, focusing on changing proportions of juveniles 5–19 years of age, suggests that fertility rates rose steadily during both the second and the first millennia BC. The gradual pace of the demographic transition was probably related to the low initial productivity of maize.

Bocquet-Appel (2002, 2008, 2011) has developed a new perspective on the demographic transition associated with the emergence of agriculture, termed the “Neolithic demographic transition” (NDT). Building on the observation that shifts from hunting and gathering to agricultural economies stimulated population growth, Bocquet-Appel looks for the effects of higher birthrates in Neolithic cemeteries. The proportion of juveniles in a single-period cemetery provides clues to the onset of higher birthrates in Neolithic cemeteries. The proportion of juveniles 5–19 years of age, suggests that fertility rates rose steadily during both the second and the first millennia BC. The gradual pace of the demographic transition was probably related to the low initial productivity of maize.

There is considerable noise in such data, but Bocquet-Appel (2002, 2008) has developed a new perspective on the demographic transition associated with the emergence of agriculture, termed the “Neolithic demographic transition” (NDT). Building on the observation that shifts from hunting and gathering to agricultural economies stimulated population growth, Bocquet-Appel looks for the effects of higher birthrates in Neolithic cemeteries. The proportion of juveniles in a single-period cemetery provides clues to the age structure of the originating population. The focus is on individuals aged 5–19 years, because very young individuals (0–4 years) are often absent or underrepresented in prehistoric cemeteries (Bocquet-Appel and Naji 2006:341–342). The proportion of juveniles (5–19 years old) relative to all individuals five years or older is a paleodemographic indicator highly correlated with the birthrate (Bocquet-Appel 2002:638–643). In growing populations, the proportion of young individuals is high, whereas in shrinking populations it is low. Therefore, we would expect growing populations to generate cemeteries with high proportions of 5–19-year-olds, a statistic abbreviated as \( \frac{J}{P_5} \). Stationary or declining populations would yield cemeteries with low values of \( \frac{J}{P_5} \).

There is considerable noise in such data, but Bocquet-Appel was able to identify an NDT in prehistoric Europe by introducing a relative chronology based on the wavelike spread of agriculture across the continent. The absolute age of each cemetery was converted into a chronological position relative to the local arrival of the Neolithic (dt). The leading edge of the Neolithic expansion always corresponded to dt = 0. Values of dt for Mesolithic cemeteries therefore were negative, whereas those for Neolithic cemeteries were positive. With the data aggregated in this way, a distinct rise in values of \( \frac{J}{P_5} \) with the initial Neolithic, signaling a rise in the birthrate, is identifiable (Bocquet-Appel 2002, fig. 4). Extensions of these techniques have identified similar demographic transitions in multiple world areas (Bocquet-Appel 2008), including the Levant (Guerrero, Naji, and Bocquet-Appel 2008), North America generally (Bocquet-Appel and Naji 2006), and the U.S. Southwest in particular (Kohler et al. 2008).

In this paper, we present a comparable analysis for Mesoamerica. Previous considerations of the NDT in this region did not involve an effort to assemble the skeletal evidence (Bandy 2005; Lesure 2008). Results suggest that the NDT in Mesoamerica was a gradual process that unfolded over the entire Formative period (1800 BC–AD 200).

Data and Methods

Our data set includes information on 2,250 Formative, 2,296 Classic, and 2,158 Postclassic burials compiled primarily from published records (see table 1; for references, see table A1; tables A1, A2 available online). Archaic burials (table A2) are too few for meaningful analysis. Figure 1 presents a simplified Mesoamerican chronology, and figure 2 gives a map of sites. In this section, we briefly summarize methodological issues and challenges.

Skeletal Samples

Pre-Hispanic cemeteries are rare in Mesoamerica. Burials were often around residences, resulting in small excavated assemblages. We have used particularly residential assemblages that include individuals of a range of ages. Following Kohler et al. (2008), we have in numerous instances pooled small samples from the same region and period (table A1). For comments on our rejection of certain cases, see section 1 of supplement A, available online.

For the Formative era, we set a minimum sample size at 11 because below that the expected number of juveniles (5–19 years) for a population with zero growth falls below 2. For urban communities of the Classic and Postclassic, a sample size of 11 hardly seemed acceptable. For those periods we required a minimum sample size of 22 (twice that for the Formative).

Ages Estimates

Calculation of the paleodemographic indicator used to detect the NDT (\( \frac{J}{P_5} \)) requires that ages 0–4 years be distinguished from 5+ years and that 5–19 years be distinguished from 20+ years. Many Mesoamerican burials are not published at the required level of detail. Published age breakdowns often...
Table 1. Samples used in the analysis

| Sample code | Phase or period midpoint | Sites | Earliest ceramics in years | $n$ (5–19) | $n$ (5+ | $\delta^{13}C$
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CM1</td>
<td>250 BC</td>
<td>Chupicuaro (20)</td>
<td>1000</td>
<td>64.4</td>
<td>311.4</td>
<td>.21</td>
</tr>
<tr>
<td>CM2</td>
<td>AD 650</td>
<td>La Mesa (40)</td>
<td>1700</td>
<td>14.15</td>
<td>46.8</td>
<td>.30</td>
</tr>
<tr>
<td>CM3</td>
<td>AD 1000</td>
<td>Tula (73)</td>
<td>1700</td>
<td>13.89</td>
<td>63.8</td>
<td>.22</td>
</tr>
<tr>
<td>CM5</td>
<td>AD 1210</td>
<td>Cholula (19)</td>
<td>1700</td>
<td>88.81</td>
<td>380.4</td>
<td>.23</td>
</tr>
<tr>
<td>CM6</td>
<td>650 BC</td>
<td>Chalcatzingo (14), Guayupita (32), Nexpa (46)</td>
<td>1800</td>
<td>13.8</td>
<td>100.8</td>
<td>.14</td>
</tr>
<tr>
<td>CM7</td>
<td>1100 BC</td>
<td>Chalcatzingo (14), Zacatenco (78)</td>
<td>1800</td>
<td>4</td>
<td>23</td>
<td>.17</td>
</tr>
<tr>
<td>CM8</td>
<td>800 BC</td>
<td>El Arrollillo (27), Zacatenco (78)</td>
<td>1700</td>
<td>9</td>
<td>58</td>
<td>.16</td>
</tr>
<tr>
<td>CM9</td>
<td>400 BC</td>
<td>Buenaventura (9), Terremote-Tlatenco (64), Tapacoya (70)</td>
<td>1700</td>
<td>20.54</td>
<td>113.2</td>
<td>.18</td>
</tr>
<tr>
<td>CM10</td>
<td>AD 425</td>
<td>Teotihuacan: various residential contexts (62)</td>
<td>1200</td>
<td>72.79</td>
<td>349.2</td>
<td>.21</td>
</tr>
<tr>
<td>CM11</td>
<td>400 BC</td>
<td>Ticoman (65)</td>
<td>1700</td>
<td>8.5</td>
<td>54.5</td>
<td>.21</td>
</tr>
<tr>
<td>CM12</td>
<td>1200 BC</td>
<td>Tlatilco (71)</td>
<td>1700</td>
<td>54</td>
<td>329</td>
<td>.16</td>
</tr>
<tr>
<td>CM13</td>
<td>AD 1423</td>
<td>Tenochtitlan (60)</td>
<td>1700</td>
<td>48.49</td>
<td>280.8</td>
<td>.17</td>
</tr>
<tr>
<td>CM14</td>
<td>AD 1300</td>
<td>Teotenango (61)</td>
<td>1700</td>
<td>89.59</td>
<td>391.2</td>
<td>.23</td>
</tr>
<tr>
<td>WM1</td>
<td>AD 1200</td>
<td>Alta Vista (2)</td>
<td>600</td>
<td>2.87</td>
<td>23.5</td>
<td>.12</td>
</tr>
<tr>
<td>WM2</td>
<td>AD 685</td>
<td>Chalpa (15), Juana Gomez (37), Penales (48), Tecuilla (59)</td>
<td>1000</td>
<td>17.3</td>
<td>105.1</td>
<td>.16</td>
</tr>
<tr>
<td>WM3</td>
<td>AD 1050</td>
<td>Guadalupe (31)</td>
<td>1700</td>
<td>16.41</td>
<td>94.4</td>
<td>.17</td>
</tr>
<tr>
<td>WM4</td>
<td>1250 BC</td>
<td>El Opeño (28)</td>
<td>1700</td>
<td>29.5</td>
<td>250</td>
<td>.12</td>
</tr>
<tr>
<td>WM5</td>
<td>AD 1438</td>
<td>Ursichu (75)</td>
<td>1000</td>
<td>7.35</td>
<td>30</td>
<td>.25</td>
</tr>
<tr>
<td>SH1</td>
<td>550 BC</td>
<td>Coatetpec (21), Cuicatlan (24), Quachilco (51)</td>
<td>1700</td>
<td>2</td>
<td>14</td>
<td>.14</td>
</tr>
<tr>
<td>SH2</td>
<td>400 BC</td>
<td>Fabrica San Jose (29), Huitzo (34), Monte Albán (45), San Sebastian Abasolo (54), Tierras Largas (66), Tomaltepec (72)</td>
<td>1800</td>
<td>10.97</td>
<td>72.6</td>
<td>.15</td>
</tr>
<tr>
<td>SH3</td>
<td>AD 500</td>
<td>Monte Albán (45)</td>
<td>1800</td>
<td>26.31</td>
<td>131.1</td>
<td>.20</td>
</tr>
<tr>
<td>SH4</td>
<td>1400 BC</td>
<td>San Jose Mogote (52), various sites (34, 66, 72)</td>
<td>1800</td>
<td>10</td>
<td>97.17</td>
<td>.10</td>
</tr>
<tr>
<td>SH5</td>
<td>800 BC</td>
<td>Various sites (29, 34, 66, 72)</td>
<td>1800</td>
<td>5</td>
<td>35</td>
<td>.14</td>
</tr>
<tr>
<td>EM1</td>
<td>750 BC</td>
<td>Chiapa de Corzo (16), Mirador (43)</td>
<td>1700</td>
<td>2.5</td>
<td>15.5</td>
<td>.16</td>
</tr>
<tr>
<td>EM2</td>
<td>400 BC</td>
<td>Chiapa de Corzo (16), Mirador (43)</td>
<td>1700</td>
<td>11.2</td>
<td>53.2</td>
<td>.21</td>
</tr>
<tr>
<td>EM3</td>
<td>75 BC</td>
<td>Chiapa de Corzo (16)</td>
<td>1700</td>
<td>3</td>
<td>15</td>
<td>.20</td>
</tr>
<tr>
<td>EM4</td>
<td>AD 75</td>
<td>Chiapa de Corzo (16)</td>
<td>1700</td>
<td>8.1</td>
<td>52.1</td>
<td>.16</td>
</tr>
<tr>
<td>EM5</td>
<td>1500 BC</td>
<td>Chilo (17), Paso de la Amada (49), Vivero (76)</td>
<td>1900</td>
<td>4.97</td>
<td>30.4</td>
<td>.16</td>
</tr>
<tr>
<td>EM6</td>
<td>AD 1</td>
<td>Dzibilchaltun (26)</td>
<td>900</td>
<td>1.3</td>
<td>12.3</td>
<td>.11</td>
</tr>
<tr>
<td>EM7</td>
<td>AD 1300</td>
<td>Mayapan (42)</td>
<td>900</td>
<td>45.78</td>
<td>217.78</td>
<td>.21</td>
</tr>
<tr>
<td>EM8</td>
<td>AD 775</td>
<td>Dzibilchaltun (26), Oxkintok (47), Xuenkal (77), Tancan (57)</td>
<td>900</td>
<td>31.82</td>
<td>104.7</td>
<td>.30</td>
</tr>
<tr>
<td>EM9</td>
<td>AD 1492</td>
<td>Iximche (36)</td>
<td>1000</td>
<td>19.37</td>
<td>102.5</td>
<td>.19</td>
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required probabilistic conversions of categories that cross one or both ends of the 5–19 interval. We developed a set of rules—inspired by those of Bocquet-Appel (2002, online supplement)—for calculating $n$ for 5–19 years and $n$ for 20+ years for the skeletal assemblages listed in tables 1 and A1. The rules are provided in supplement A (section 2). Also provided is a report on how changes to those rules would affect results (section 4).

**Chronological Issues**

In previous studies of the NDT, relative chronology makes the phenomenon detectable (Bocquet-Appel 2002; Bocquet-Appel and Naji 2006; Guerrero, Naji, and Bocquet-Appel 2008; Kohler et al. 2008). The use of relative chronology is most clearly appropriate for cases in which agriculture spread from an initial heartland. In such cases, a relative chronology aligns diverse sequences with respect to the phenomenon of interest, the transition to an agricultural economy. Bellwood (2005:237–244) proposes a plausible perspective on how the transition to maize as a staple in Mesoamerica might have generated population expansions from multiple heartlands. However, that scenario is not reliable enough to provide a relative chronology for present purposes. It is even debatable how to set the 0 point of the relative chronology for Mesoamerica (Lesure 2008:109), although in our view the only viable choice is the shift from Archaic to Formative, a moment that has the advantage of an identifiable proxy in the appearance of pottery (in each case, well-fired ceramic containers). That transition occurred simultaneously at 1800 BC in numerous regions across Mesoamerica; however, in the Maya Lowlands it was delayed by some 700 years (Clark and Cheetham 2002, fig. 2).

In one version of our analysis, we use a relative chronology with $dt = 0$ for each region set at the time of the local appearance of ceramics. However, we argue that an absolute chronology produces more intelligible results. Kohler and Var- rien (2010, fig. 3.2) have also shifted to an absolute chronology in recent work on the NDT in the U.S. Southwest (cf. Kohler et al. 2008).

Phase (or period) beginning and ending dates for each sample are provided in table A1. Our calculations presented here use phase midpoints (table 1) to place samples in time. In supplement A (section 5) we report on experiments with alternatives to phase midpoints. Sometimes the phase of burials is uncertain; we have tended to use period designations (Classic, Postclassic, etc.) to allow for larger sample sizes. However, we have rejected burials classified only as Formative or Preclassic, insisting instead on divisions within that era—Early Formative, Middle Formative, and so forth.

**Reporting of Results**

Figures 3 and 4 are two visualizations of pre-Conquest Mesoamerican skeletal data, the former in relative time and the latter in absolute time. The Y-axis represents $^{13}P_2$. An important feature of the charts that will merit discussion below is the dotted horizontal line at the value of $^{13}P_2 = 0.17$. This we have adopted from Bocquet-Appel (2002, fig. 4). It represents the expected proportion of juveniles in cemeteries of a stationary population (Bocquet-Appel 2002:638–643). Following previous studies of the NDT, we use a loess curve...
(a weighted linear least squares regression that serves as a kind of moving average) to explore the relationship between variables (carried out using the local polynomial regression fitting [loess] function in R ver. 2.15.3). The regression curve is calculated using a locally weighted polynomial regression. A smoothing parameter (\( \alpha \)) determines how much of the data is used to fit each local polynomial (see Kohler et al. 2008:651), taking into account the effect of outliers. Following Kohler et al. (2008), our curves are weighted by sample size. Also following Kohler et al. (2008), we compared the goodness of fit of the line in figure 4 (\( \alpha = .5 \)) with a straight line (\( \alpha = 1.0; \) SAS ver. 9.4, PROC LOESS). Comparison yields an \( F \) (df = 2.4, 47.4) = 4.22, \( P = .042 \). The loess line displays a significantly better fit than a straight line through the data points.

Results

The plot in relative time (fig. 3) is most directly comparable to studies of the NDT in other world areas. The shape of the curve, with a steep rise in \( \varepsilon P_\alpha \) from \( dt = 0 \), follows expectations based on those studies (see Bocquet-Appel 2008; fig. 1; Kohler et al. 2008, fig. 4). A departure from results for other regions (evident as well in fig. 4) is that the Mesoamerican curves begin well below \( \varepsilon P_\alpha = 0.17 \), the value expected for a population with zero growth. We consider that issue below.

Our dissatisfaction with figure 3 is based on a more subtle observation. For the first 1,000 years after \( dt = 0 \), all the high values (>0.17) of \( \varepsilon P_\alpha \) are samples from the first millennium BC that because of a later local start date for ceramics are placed alongside second millennium BC samples in the relative chronology. A Mann-Whitney \( U \)-test finds that first millennium BC samples with \( dt < 1,000 \) are significantly different from the second millennium BC sites at a 0.10 level but not at a 0.05 level (\( N_{\text{first mil BC}} = 9 \) with mean rank = 9.0; \( N_{\text{second mil BC}} = 5 \) with mean rank = 4.8; \( U = 9; \) \( P = .083 \)). The first millennium BC samples with \( dt < 1,000 \) are, instead, collectively similar to the other first millennium BC samples—that is, those for which \( dt \geq 1,000 \) (\( N_{dt \geq 1,000} = 9 \) with mean rank = 9.3; \( U = 63; \) \( P > .33 \)).

We suggest that absolute time matters—that all the first millennium BC samples actually belong together. Collectively, they have a character distinct from the second millennium BC samples. Specifically, the upper range of \( \varepsilon P_\alpha \) values is higher in the first millennium than in the preceding second millennium. Some other variable besides relative time elapsed since the local shift to sedentism/pottery/agriculture may have affected birthrates during the Formative. The variable we suggest is changing productivity of the crop complex, in particular maize.

Benz and Long (2000) and Benz et al. (2009) calculated rates of change in rachis diameter, row number, cupule width, and rachid length of accelerator mass spectrometry–dated maize cobs from dry caves in the Tehuacan Valley. Although results vary somewhat among the caves, the overall picture is that maize cobs in this region increased significantly in size in the Formative and later eras, suggesting increasing productivity. Rates of morphological change in the Formative through Postclassic were actually greater than or equal to those of the Late Archaic—Early Formative, and change may have accelerated in the first millennium BC in comparison with the preceding second millennium (Benz et al. 2009:90).

Indeed, there is growing evidence of the mixed character of subsistence during the second millennium BC. Wild foods were still important in relation to maize. It may be that it was not until after 1,000 BC that maize truly became a dietary staple (Arnold 2009; Killion 2013; Smalley and Blake 2003; VanDerwarker 2006:37; Webster 2011).

The likelihood of change in the productivity of the agricultural package during the Formative prompts us to favor figure 4, which charts \( \varepsilon P_\alpha \) values in absolute time. The curve is simple. There is a gradual increase in \( \varepsilon P_\alpha \) throughout the two millennia of the Formative. The curve crosses \( \varepsilon P_\alpha = 0.17 \) at around 600 BC and peaks around AD 1. At that point, values stabilize.

Bocquet-Appel (2002) used simulated results based on 45 life tables with preindustrial mortality to show that \( \varepsilon P_\alpha \) could be used as a proxy for birthrate. Based on figure 4, then, we would postulate a gradual NDT in Mesoamerica that extended throughout most of the Formative, with birthrates steadily increasing. The first millennium BC emerges as a crucial era.
of the Mesoamerican NDT. Fertility rates were higher at this time than in the preceding second millennium BC.

Supporting Evidence from Regional Surveys

A lengthy NDT for Mesoamerica would be consistent with patterns in other core regions of the development of agriculture (Bellwood and Oxenham 2008:30; Bocquet-Appel and Naji 2006:347; Guerrero, Naji, and Bocquet-Appel 2008:75). The idea that the first millennium BC was crucial in the demographic transition is also consistent with the observation, based on surveys across Mesoamerica, that it is particularly during the Middle Formative (1000–400 BC) that there is an explosion of population in one region after another.

Using a formula introduced by Bandy (2005) for investigating the NDT based on population data from regional surveys, figure 5 quantifies growth rates (not raw populations) over the course of the Formative for three parts of the Basin of Mexico, the Amatizinac Valley (Morelos), the Tepeaca region (Puebla), two sets of subregions in the Valley of Oaxaca, and Kaminaljuyu (Guatemala). Only growth rates greater than 0 are shown. Results are calculated by phase, making the curves a series of horizontal plateaus. Because the formula for calculating population growth involves dividing the estimated population of a given phase by the population of the previous phase, each curve begins with the second local Formative phase. Because the time of initial settlement in each area is nevertheless of interest, we have introduced a dotted line in each case from the beginning of each curve down to a value of zero growth at the beginning of the local Formative; it should be remembered that the actual value for growth in each initial phase is unknown. Castanzo (2002) did not identify any Early Formative occupation in the Tepeaca region but estimated 14,557 people in the Middle Formative; in order to register this remarkable growth, we have assumed that he missed a population of 200 in the Early Formative.

The cases illustrated reveal explosive growth during the Middle Formative, generally tapering off before the end of the first millennium BC. For the Valley of Oaxaca (cases 6 and 7), Bandy’s (2005) proposed Early Formative NDT—signaled by a rise and subsequent drop in growth rate—is evident, as are the higher Middle Formative growth rates previously remarked on by Lesure (2008:131–133); both episodes should now be seen as part of an extended NDT. Middle Formative growth was particularly explosive in areas adjacent to centers of Early Formative population concentration (cases 1, 2, 5, and perhaps 7). It is noteworthy, however, that even in Early Formative “heartlands” (cases 3, 4, 6), the Middle Formative witnessed a significant additional phase of growth.
that outstripped any rates registered before 1000 BC. Overall, the cases examined support the idea of a lengthy NDT with the first millennium BC a key era in the demographic transition.

**Low Proportions of Juveniles**

In sum, interpretation of figure 4 as a general representation of changing birthrates in pre-Conquest Mesoamerica and evidence of a lengthy demographic transition extending throughout the Formative fits with other Mesoamerican data. There remains, however, the puzzle that the actual values observed for \( \alpha \) in Mesoamerica are persistently below those observed for other world regions (fig. 6). Early Formative Mesoamerican values begin well below the value expected of a stationary population (the horizontal dotted line). During the course of the NDT, they rise to a level only modestly above that. If we were to postulate that the low Early Formative values from Mesoamerica constitute a sampling error, with actual values around 0.17, then we would essentially wipe out any trace of an NDT signature for the Formative.

Could there be a pervasive, systematic bias in our data resulting in artificially low values of \( \alpha \) for Mesoamerican burial assemblages? Certainly there are reasons for caution concerning the quality of the available data (see supplement A for details). Age classifications in published reports are often crude. In the later Formative and Classic periods, excavations biased toward monumental site centers or elite contexts may yield assemblages in which adults are overrepresented. Still, given the momentous social changes in Mesoamerica from initial Formative to Late Postclassic and the diversity in burial practices between regions and time periods, we find it implausible that a single biasing factor such as a systematic underrepresentation of children could uniformly pervade the entire pre-Hispanic burial record.

Let us instead reconsider \( \alpha = 0.17 \) as the expected value in a stationary population and more generally the relation between \( \alpha \) and the growth rate. Bocquet-Appel’s simulated stationary populations suggested that \( \alpha \) could be used as an estimator of both birthrate and growth rate; the value of 0.17 for a growth rate \( r \) of 0 derives from the equation generated in that study, \( r = -0.05389 + 0.12555 \times (\alpha)0.47788 \) (Bocquet-Appel 2002, table 2). However, the relation between \( \alpha \) and growth rate is likely to be more complicated than originally postulated. Bocquet-Appel (2008:46–52) seems to admit as much in a later publication, when he suggests that increased mortality balanced the Neolithic increase in fertility to yield growth rates of 0.1%–0.2%, much more modest than values generated in the formula for \( r \) given variation in \( \alpha \) from the 2002 publication. This suggestion undermines confidence in the value of 0.17 as a lower threshold for \( \alpha \) in stationary populations because there is no systematic relation between \( \alpha \) and mortality (Bocquet-Appel 2008:48).
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Figure 4. Observed profile of \( { }^{15}P_5 \) on an absolute chronology (BC/AD). Relationship fitted using a loess fitting procedure (\( \alpha \) [smoothing parameter] = .5; \( n \) observations = 52).

We propose to accept \( { }^{15}P_5 \) values from Mesoamerica as a proxy for birthrates but not growth rates. The unusually low values of \( { }^{15}P_5 \) in Early Formative assemblages (in comparison to early Neolithic values from other world areas) may be a symptom of lower productivity of the Mesoamerican agricultural package, particularly in its early stages. However, there is a remaining problem to be addressed: why does the NDT curve for the U.S. Southwest diverge so dramatically from that for Mesoamerica?

Mesoamerica and the U.S. Southwest

The \( { }^{15}P_5 \) curve for the U.S. Southwest falls in among Old World cases, while \( { }^{15}P_5 \) values for Mesoamerica are distinctly lower (fig. 6). At first glance, this result seems to undermine our suggestion that low values for Mesoamerica were the result of the modest expansionary potential of the initial agricultural package. Because the Southwest received its important crops from Mesoamerica, it is tempting to treat the crop complexes in the two cases as essentially the same. But were they really the same? We suggest that the agricultural packages that fueled NDTs in the two cases were not the same. A significant difference was that the two NDTs drew on the shared crop complex at different points in absolute time and therefore different moments in the development of the crops.

Figure 7 places the two curves together on an absolute timescale. The Southwest data are from Kohler et al. (2008, table 1), with the addition of a single first millennium BC sample from La Playa, Sonora (Watson 2005). In the Southwest case, we have eliminated samples with \( n \) (5+) < 11, the rule we have used to screen our Formative samples. In the figure, the NDT in the Southwest is clearly evident, beginning approximately AD 500 and thus some 2,300 years after the initiation of a much more gradual NDT, with lower associated birthrates, in Mesoamerica.

The NDT in Mesoamerica began at the Archaic-Formative transition based on relatively unproductive maize with small cobs (Kirkby 1973:126; see also Benz and Long 2000; Benz et al. 2009). Fertility increased slowly from the initial Formative. In the U.S. Southwest before about AD 500, values of \( { }^{15}P_5 \) coincide with those of the same era in Mesoamerica. It is only with the onset of the NDT that values soar rapidly. We conclude that the NDT in the Southwest, beginning about AD 500, started from a fertility baseline that was essentially the same as that of contemporary sites in Mesoamerica. In the more marginal desert environments of the Southwest, the shared agricultural package of the second and first millennia BC was probably not sufficiently productive to fuel even a gradual NDT such as transpired in Mesoamerica. It was only with the development or introduction of new varieties of maize in the first millennium AD—along with other developments such as pottery, locally effective storage techniques,
Figure 5. Eight cases of Formative-era population growth per year calculated from settlement data using a formula introduced by Bandy (2005). The era between 1000 and 400 BC is the Middle Formative. Data sources: Blanton (1972), Blanton et al. (1982), Gorenflo and Sanders (2007), Kowalewski et al. (1989), Michels (1979), Parsons (2008), Parsons, Kintigh, and Gregg (1983).
and social mechanisms facilitating exchange (Kohler et al. 2008:662)—that the NDT arrived in the U.S. Southwest.

Aside from the gap in time between the two NDTs, the two other features that distinguish the NDT of the Southwest from that of Mesoamerica are its more sudden, explosive character and its higher associated birthrates. To some extent, these differences may be expected when a secondary region is compared with a primary region of agricultural origin (Bellwood and Oxenham 2008:30). The NDT of the Levant, however, though gradual, yielded birthrates similar to those in regions of the secondary spread of the Levantine agricultural complex (fig. 6). The higher birthrates achieved during the NDT in the Southwest (compared with Mesoamerica) may be related to the more productive agricultural package on which it was based. By the first millennium AD, Mesoamerican skeletal assemblages are characterized by lower proportions of young individuals 5–19 years of age throughout the NDT. We attribute this pattern to the initially low productivity of the Mesoamerican agricultural complex. The higher birthrates that characterize the NDT in the U.S. Southwest may be attributed to the different historical moment of the Southwestern NDT: the demographic transition in the Southwest, from AD 500, was based on a significantly more productive crop complex than that of the second millennium BC, when the Mesoamerican NDT began.

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Conclusion
Our analysis of data from pre-Conquest Mesoamerican burials suggests that the demographic transition associated with the emergence of an agricultural economy extended throughout the two millennia of the Formative era. In comparison to other world regions, including the U.S. Southwest, Mesoamerican skeletal assemblages are characterized by lower proportions of young individuals 5–19 years of age throughout the NDT. We attribute this pattern to the initially low productivity of the Mesoamerican agricultural complex. The higher birthrates that characterize the NDT in the U.S. Southwest may be attributed to the different historical moment of the Southwestern NDT: the demographic transition in the Southwest, from AD 500, was based on a significantly more productive crop complex than that of the second millennium BC, when the Mesoamerican NDT began.
Figure 7. Comparison of separately observed profiles of \( \alpha_{p5} \) from Mesoamerica and the U.S. Southwest on an absolute chronology (BC/AD; \( \alpha = .5 \); \( n \) observations = 52, 46). A color version of this figure is available online.

References Cited


