How Many Philistines and Other Outside Groups Arrived in Canaan?

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Abstract

The number of the Sea People arriving into Canaan at the end of the Late Bronze Age is heavily disputed: from a few thousand to ca. 25,000. Unfortunately, the archaeological evidence cannot support or refute any of these paradigms. To this end, a model for determining population demographics during periods of scarce archaeological information is presented. The model (i) interpolates the total population during the Iron Age I, **including** the newly arrived peoples, based on data available from the two adjacent archaeological periods, for which there is a better demographic understanding: the Late Bronze IIB and the Iron Age II, and (ii) subtracting that result from the theoretical scenario assuming zero immigration or emigration. The above theoretical outcomes are examined alongside the archaeological and historical records of the three mentioned periods.

The primary traits of the model are:

1. All the input data should be derived **solely** from archaeological excavations and survey reports, followed by an error estimation.
2. All the mathematical-statistical techniques used will be **well recognized** and frequently used within these two scientific disciplines.

The final estimate for the Philistines and other non-local populations during the Iron Age I achieved here is ca. 24,000, assuming a specific error of 12%.

Keyboards: Iron Age I, Philistines, Shephelah, Coastal Plain, Demographic.

1. Introduction

The Iron Age I was a period of vast immigration and significant demographic increase in Canaan (Sharon 1990: 25; Stager 1998: 134-136; Herzog 1999: 48; Faust 2013: 204). Na'aman (1996: 25) assumes that this increase (spoken of in 1 Kings 4:20) enabled the emerging state to allocate more people for corvée work (1 Kings 5: 29-32). Na'aman (1990: 309) also shows that in addition to the invasion of the Sea Peoples, additional groups of people entered Canaan during Iron Age I. This includes immigrants from Asia Minor, North Mesopotamia, and Egypt.

Direct archeological data leads Finkelstein (2000: 172-173) to number the Philistines at a few thousands. The continuity of material culture in Canaan after the Philistines' arrival brings Bunimovitz (1990: 219) to the same conclusion. This low estimate is contra to Stager (1995: 344) who assumes that the Philistines occupied the Pentapolis and that their numbers was ca. 25,000. Singer (1990: 366-367) also comes to a similar estimation. Yasur-Landau (2010: 110) proposes that the Sea Peoples needed at least 600 men just to establish the bridgehead. On the other hand, Hitchcock and Maeir (2014) reject the simplistic notion of a massive migration or of an Aegean colonization and instead suggest that the invaders were ethnically and culturally mixed tribes of pirates. Today it is wide accepted that the organization of human resources for migration was beyond the power of a single small community (Yasur-Landau 2010: 111). In addition, a prior condition for such a migration is having prior knowledge of the final destination, as suggested by Voskos and Knapp (2008: 679) and Anthony (1990).

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A second drawback of the proposed model stems from the limited archaeological methodologies existing today. This requires some further explanation.

Various methods have been developed to estimate demographic size from archaeological data (Hassan 1981; Kramer 1982: 116-119; Chamberlain 2006; Porcic 2011: 323; Faust and Safrai 2015). Still, at this stage, archaeological surveys are not standardized in their methodologies (Tavger *et al.*, 2016) or in manner of publication, preventing reasonable correlations between them. Also, there is no consensus regarding the density constants (Kramer 1982: 196-197; Finkelstein 1990: 47; Porcic 2011: 323-324), which tend to be higher for towns than for villages and increase with time (Kramer 1982: 134, 148, 172). In various cases the field results need correction factors (or "error coefficients") before being publically reported. For example, in one case, Finkelstein (1988: 332), uses an error coefficient of 300% (!) while Lipschits (2003: 363) uses 30%. These factors can neither be justified nor refuted.

Due to these inherent restrictions, it was decided that, at this work, all the archaeological data applied will be selected from excavation and survey reports produced by the same scholars – as all this data was gathered and reported using the same procedures. On the other hand, bringing archaeological data belonging to the same period and region that was generated by other archaeologists onto common ground is beyond the scope of this paper.

2. Mathematical - Demographical Approaches

The computation procedure includes two stages. The first, described in this paragraph, includes statistical calculations assuming constant natural growth and zero immigration. In the second stage, the above theoretical outcomes are studied together with real archaeological and the historical records belonging to that period.

The mathematical approach can be assumed either as an unconstrained or constrained growth. The unconstrained model uses an exponential behavior, meaning that the results depend only on the initial population size and the annual growth rate (Schacht 1980; Kramer 1982):

$$Pt = Po \cdot e^{rt}$$

Where Pt is the population at time t, Po is the initial population size, r is the rate of growth per annum and t is the time span in years between Pt and Po.

Empirically speaking, a pattern of exponential increase can be expected only for a few centuries. For longer periods the constrained model should be applied, as, in these conditions, further population growth would be limited by the restricted carrying capacity of the land. In this case a logistic behavior shall exist:

$$Pt = \frac{K}{1 + \left(\frac{K - Po}{Po}\right)e^{-rt}}$$

Where K is the carrying capacity, related to the maximum population possible for a certain area. Specifically, this approach would be affected according to how close the settled population is to the maximum carrying capacity (Schacht 1980: 783-785). In its limited case, where $Po = K$, the value of Pt would also be equal to K.

Generally speaking, the exponential approach would be preferred during the early phases of population growth whereas the logarithmic model would give more realistic results when the population numbers approach the carrying capacity of the land, especially when dealing with agrarian societies. It should also be mentioned that, whereas the exponential approach has only two unknown constants, Po and r, the logarithmic approach has three, Po, r. and K. Estimating K, however, may become a difficult task as the carrying capacity factor is a complex function of environment, technology, as well as social and political stability (Schacht 1980: 786-787; Kramer 1982: 190). It should be emphasized that both mathematical-statistical approaches described above are conventional procedures in the field of demographic studies.

3. The Diachronic Model

The archaeological approaches are mainly concerned with "frozen slices" of history records, and thus present a "synchronic approach". On the other hand, mathematical approaches are inherently based on long and un-altered conditions, and thus present a "diachronic approach". The diachronic model integrates both approaches.

The outcome of the first stage would yield "theoretical" figures as might occur under ideal conditions. The "empirical" results, added to the above in the second stage, are based on excavation results and field surveys.

A huge difference between the "theoretical" and the "empirical" figures may indicate an irregular demographic event, as will be demonstrated in the following.

A fundamental requirement for the "diachronic model" is that all the data necessary for its implementation would be provided by the archaeological reports only. As the archaeological surveys in Israel are not performed today using a standardized method (Tavger *et al.,* 2016), utilizing different sources in the same analysis should be avoided. Thus, the implementation of the model, at this stage, will be limited to the works used jointly by Finkelstein, Broshi and Gophna, as shown in the Appendix.

The model for the Iron Age I is based on interpolations from two eras of relative proliferation during which the demographic data is more comprehensive: the LB IIB and the Iron Age II. To increase statistical reliability, the criteria for selecting the specific year for the eras of proliferation are: they should be as long as possible; therefore, they are chosen as close as possible to periods of instability, but still in the "stable" zone (e.g., before the first Assyrian campaigns) or prior to "catastrophic" events (e.g., the invasion of the Sea Peoples).[2]

The date of ca. 1210 B.C.E.- used specifically in this model - represents the end the long, peaceful and prosperous period following the Egyptian–Hittite peace treaty and before the collapse of the international global order of the LB IIB, and close to Merneptah's campaign.[3] This concept is called here "the first proliferation datum". The second proliferation datum is in ca. 740 B.C.E., shortly before Tiglath Pileser III's first campaign to Philistia in ca. 734 B.C.E. This campaign started the decline of the area and included the conquest of Samaria, ensuing deportations, widespread destruction, and much loss of life (Broshi and Finkelstien 1992: 55). The selected analyzed year for the Iron Age I is ca. 1010 B.C.E., shortly before the rise of the Israelite monarchy.

In the following, the exponential approach will be adopted due to two reasons: (i) it is simpler than the logarithmic approach as it does not require the introduction of the constant K which requires additional assumptions,[4] and, (ii), even the high population rate of the Iron Age II (97,000 people) is still far from the maximum carrying capacity of the combined area (ca. 260,000), at which point the model becomes constrained (Schacht 1980: 783-785). Nevertheless, the results of the logarithmic approach are also presented in the Appendix.

Figure 1 demonstrates the principles of the calculation process while the details are presented the Appendix. The first stage of the calculation process is to estimate r, the annual rate of growth (Eq. A2; Eq. A5, of the Appendix).

Using the logarithmic approach (Eq. A2), a growth rate of $r = 0.0016$ is reached, while that of the exponential approach (Eq. A5) gives a similarly close result of $r = 0.0014$. These values comply with the range of the annual growth found in the Neolithic period, 0.001-0.03 (Porcic 2011: 327).

Once r is estimated, the interpolation process is possible. The record for the two initial points was available from archaeological data: (1) for the LB IIB, at a population of ca. 34,000, and (2) for the Iron Age II, at a population numbering of ca. 97,000. In this example, the two exponential interpolations intercept at 1010 B.C.E. at the numerical values of ca. 45,000 and ca. 67,000, respectively.

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[2]It is worth emphasizing that the statements "stable" and "catastrophic" are artificial terms which do not exist in "real" history. These expressions are intended to present two negative extremes of the political, economic, and social situation.

[3]Leading scholars used to date Merneptah's campaign to 1209-1208. Recently, Wiener (2014: 52) suggests placing the date at 1220-1215 B.C.E.

[4]The assumption presented in the Appendix is that the partial K selected for our specific territory here is linearly related to the overall K of the whole land (Table A3 and A4). This assumption might be controversial as it assumes that the fertility of the land is equal in each part of the territory.
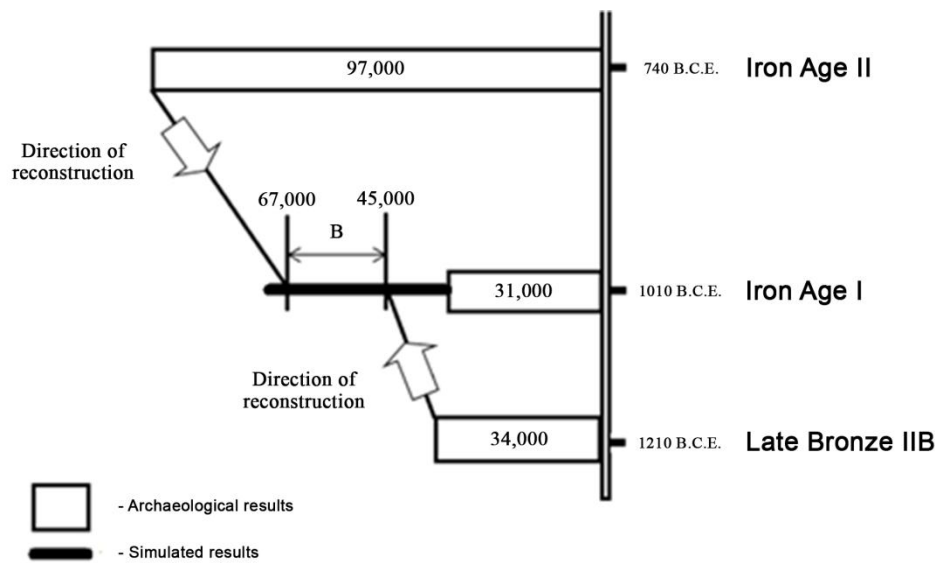
Figure 1: Simple schematic demonstrating the diachronic approach.

Note: The schematic linear presentation of the direction of reconstruction is drawn for the sake of simplicity.

4. Discussion

The characters of the two separate interpolations intersecting at 1010 B.C.E. are quite different. The first period, starting at the LB IIB, was highly susceptible to external changes. In their earlier, Monochrome stage, the Sea Peoples invaded Canaan, changed the demographic situation and settled in the Pentapolis. Later on, during the Bichrome stage, the Philistines expanded their territory (Stager 1995: 336). Fantalkin *et al.*, (2015: 37), based on ^{14}C, estimate that the transition from Monochrome to Bichrome took place between 1098 – 1035 B.C.E., probably early in this range.[5] Several scholars claim that it is highly unlikely that the local Canaanite population was harmed significantly by the Sea Peoples (Bunimovitz 1990: 219; Finkelstein 1996: 236), while little evidence suggests that their sites suffered substantial destruction (Maeir and Hitchcock 2016) as is also supported by the continuity of the Canaanite material culture.

Broshi and Finkelstein (1992: 55) show that the 250 years between the foundation of the Israelite monarchy and the beginning of the Assyrian campaigns was peaceful, and characterized by extensive agricultural development. Various scholars (Ussishkin 1990: 74; Fantalkin and Finkelstein 2006: 26-27) assume that Sheshonq I's campaign in ca. 926/925 B.C.E. (1 Kings 14: 25) was aimed at re-establishing an Egyptian political and economic grip on the region and increasing the prosperity of the south. This claim is further supported by the Egyptian policy of keeping a "low profile" in Ancient Israel at the beginning of the 22nd Dynasty (Finkelstein 2014: 98; Ben-Dor Evian 2015: 17-18). Fantalkin and Finkelstein (2006: 27) mention additional Egyptian records from Buseirah in the heartland of Edom as well as from Samaria. Broshi and Finkelstien (1992: 55) also assume that the wars between Judea and Israel and the persistent strife between Israel and the Aramaeans did not affect the demographic growth.

The interpolation process starts at the Iron Age II and intercepts with 1010 B.C.E. line at a population of 67,000. The theoretical meaning of this result is: an initial population of 67,000 people is needed, at ideal conditions, in the Iron Age I, to yield 97,000 people by the Iron Age II. The natural growth of the local population from the LB IIB can explain only 45,000 (Figure 1) of this sum, thus this difference "B" of 22,000 people may be assumed to be an external contribution of the Sea Peoples and others immigrants. On the other hand, the "empirical" demographic record in the Iron Age I, indicates a population of 31,000 only. So, where are the 36,000 "invisible" people? The opportunity to validate the existence of the "invisible" population appears when they have the ability to change their poor and scattered accommodations into regular sedentary places. This is to say, when their existence can be more easily recognized by conventional archaeological practices. This should be further explained.

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[5]Considering that the next transition in the Aegean or Aegean-related sequence (between Sub-Mycenaean and Early Proto-Geometric) took place in the second half of the 11th century B.C.E.

Following the Philistines' settlement in Canaan, they adopted a clear urban policy: to seize and to enlarge the existing Canaanite cities that they had conquered (Finkelstein 1996: 232) which led various scholars to suggest that they even used a forced urbanization policy for the local population (Faust 2013: 208). Bunimovitz and Lederman (2011: 45-46) suggest that Canaanite rural and urban populations were displaced from their dwellings and relocated in the main Philistine centers. It is also possible that some of the local sedentary population fled from their homes[6] as a result of the great fear inspired by the Sea Peoples, even prior to their arrival.

Under these circumstances, these refugees had to conform to non-durable, poor or provisional accommodations such as huts and tents. A major part of these accommodations tend to have a short durable life (Finkelstein 1992: 87-88; Gonen 1992: 148) and would require specific methods and expertise for excavation and reconstruction (Rosen 1992: 75; 2011: 73-72). Unfortunately these unique methods were not used by all archaeologists. Also, the limited resources of these refugees prevented them from creating a rich repertoire of wares, thus requiring a greater level of effort, expertise, and caution on the part of the archaeologist in order to find them (Rosen 1992: 77). In addition, Finkelstein and Perevoletsky (1989: 14; 1990: 71) suggest that in this environment, the number of small and poor sites would be significantly increased while these new groups would start to adopt characteristics of nomadic behavior or to gather in tribal societies – as has been reported for the Shephelah by Lehmann and Niemann (2014: 77, 85). Dagan (2011: 254) also describes the earlier Iron Age population in the Shephelah as "sporadic" but with some quite substantial settlements.

5. Results

1. As shown in Figure 1 and in Figure 2 of the Appendix, a zero error assumption will suggest ca. 45,000 for the local Canaanite population and ca. 22,000 for the population of the Philistines and other non-local peoples (i. e., B = 67,000 – 45,000).
2. From the local estimate of ca. 45,000, only ca. 31,000 are identified – so far – by archaeological records; whereas, ca. 14,000 are "unseen", possibly because they were dwelling in poor and scattered accommodations.
3. If a specific error of 12% is selected for the settled area yet unrevealed through excavation or surveys, then, the estimate of the local Canaanite population will rise to ca. 50,000 and that of the Philistines and other non-local populations will rise to ca. 24,000 (Figure 2).
4. If a specific error of 5% is selected for r, then, the estimate of the local Canaanite population will change to ca. 45,500 while that of the Philistines and other non-local populations will decrease to ca. 19,800 (Figure 3).
5. Therefore, assuming that the majority of the non-local peoples were Philistines, then the results may support Stager's (1995: 344) estimation that the Philistines number ca. 25,000, and not the simply a "few thousands" (Finkelstein 2000: 172-173; Bunimovitz 1990: 219). The contra to this assumption will lead to the opposite result.

6. Conclusions

1. Synchronic demographic estimations based on "conventional" archaeological procedures may lead to underestimated figures during intermediate and unstable periods for which not all the non-durable built-up areas are easily detectable by archeological excavations and field surveys. In these cases, performing diachronic interpolation is recommended.
2. In this case study, direct archaeological evidence in the Shephelah and the Southern Coastal Plain in the Iron Age I attest to a population of only 31,000 people, whereas diachronic simulation predicts an additional population of 36,000 "invisibles".
3. These "invisibles" most likely lived in "sporadic" sites (Dagan 2011: 254) and had to conform to poor, non-durable accommodations. Their small settlements and farms are generally hard to locate and identify through survey methods (Shavit 2008: 137).
4. The unique opportunity to validate the existence of the "invisibles" appears when this population changes its poor and scattered accommodations into regular sedentary settlements, which is to say, when their existence can be more easily recognized by the "conventional" archaeological practices.

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[6] See: Na'aman (1990: 309).

5. As all the data needed for the implementation of the diachronic model is to be found in archaeological reports and supported by historical records, this model should be considered as **inherently embedded in the framework of archaeological and historical knowhow** rather than in the theoretical sciences (Pollard 2004: 394).

6. If a reasonable 12% error in the settled area is assumed, then the estimated local Canaanite population will be ca. 50,000 and that of the Philistines and other non-local populations will be ca. 24,000.

7. Appendix: Detailed Calculations and Error Estimations

7.1 Introduction

Every analytical model should contain an estimation of error. On the other hand, archaeology is a unique observational science and no experiment (i.e., excavation) can ever be repeated. Thus, when a specific site is excavated, the evidence from that site is destroyed forever, except for the archaeological records collected, written reports and the remains left in the site. Therefore, "nothing can ever be checked in the scientific sense of independent replication of an experiment" and the archaeologists "are in many ways the only competent 'judge and jury' for the quality of their own work" (Pollard 2004: 392-393). Hence, although every excavation and field survey involves an error in defining the settled area, the error estimation is difficult to quantify. Instead, "corrections figures" (i.e., Broshi and Gophna1984: 41; 1986: 86-87; Lipschits 2003: 363) are proposed which can be considered only as the "best experience's assessments". Also, these corrections can neither be confirmed nor refuted. These inherent limitations are most irritating while trying to suggest error estimation in the diachronic model.

7.2 General Methodological Remarks

1. Despite years of research, today archaeological surveys are not standardized in their methods (Tavger *et al.*, 2016: 06) or manner of publication, which seriously disrupts any attempt to establish reasonable correlations between them.
2. Therefore, in order to receive – at this early stage of the model's development – meaningful results, all the archaeological data applied here should be selected from excavations and surveys using the same procedures.
3. Thus, even if the absolute demographic results achieved are inaccurate, the demographic trends would nonetheless be valuable.
4. Alternatively, in the future, the entire relevant database available should be calibrated, normalized and used.

7.3 Error Types

In order to overcome the challenging topic of error estimation in the diachronic model, it is first needed to analyze the different type of errors existing.

Four types of errors may arise in performing archaeological excavations and surveys which would directly affect the diachronic model's results:

1. The percentage of built-up area still buried in the ground. There is little doubt regarding the size of the settled area already revealed, as described in (3) below, whereas, the total settled area, partly buried, is highly speculative. This error always tends to increase the population size.

2. The annual growth rate, r (Eq. A2 and A5 in Appendix): The numerical influence of positive and negative errors of r will be discussed and demonstrated below.

3. The percentage of built-up area which is not settled: For example: (i) some of the rampart area (Broshi and Gophna (1986: 86-87). These dwelling characteristics existed in the Middle Bronze (MB) IIA but not in the Iron Age I. Thus, this case will be ignored here; (ii) the built up area in sites may have lasted for longer periods than the average lifespan of a house (Porcic 2011: 323-324), or, houses which were abandoned at a settled site (Kramer 1982). This is a basic problem, without real solution, in all demographic estimations and is not specific for the diachronic model and will be also ignored.

4. The size of the "unseen" population in ca. 1210 and in ca. 740 B.C.E.: As "common" archaeology has difficulties in providing evidence of the "unseen" population, their population contribution is difficult to assess. In these circumstances, the history record might help: strong governments prevent the existence of unauthorized military societies in their territories and prohibit free movement of fugitives and emigrants. In ca. 1210 B.C.E., the Egyptian and Hittite empires were still in power in the region and were committed by their peace treaty to extradite political fugitives and emigrants (Pritchard 1969: 200-201; Breasted 2001: 163-174). In 740 B.C.E., shortly before Tiglath Pileser III's campaign, the area was characterized by extensive agricultural development and a stable population growth (Broshi and Finkelstien 1992: 55).

Thus, in the following it will be assumed that the population size of the "unseen" component at both periods will be relatively low; also, it can be assumed that the "low" population of the first period will compensate the "low" population in the other. Therefore, this error will be also ignored here.

7.4 Error Estimation Practices

In view of the above discussion only errors (1) and (2) will be estimated in this preliminary study.

1. Error (1)'s estimation is based on the following assumption: the percentage of the built-up area still buried – at any time – is practically impossible to foresee; on the other hand, the theoretical assessment of the degree of error on the population estimation can be simply calculated through the diachronic model. Therefore, the following practice will be adopted: based on the diachronic model, tables or graphs of "built-up error" vs. the "corrected population" will be published. These tables will enable any archaeologist to select his own assessment of the error (1) figure and to receive the corresponding population correction.[7]

2. Selecting the annual growth (*r*) for this preliminary stage: Evaluating *r* is not a simple task.[8] The numerical value chosen here is based on the work of Broshi and Gophna (1986) in which 130 sites from the MB IIA and 337 from MB IIB were examined. This wide record provides good statistics reliability. Actually, the annual growth factor cannot be considered a true "constant" especially for long periods. Instead, it is rather a complex function of time, security level, technology, economy, and social behavior. The general tendency of *r* under non-crisis circumstances is to increase gradually over long durations. Thus, (i) the annual growth found in the Neolithic period starts from low values such as $r = 0.001$ (Porcic 2011: 327), and (ii) in Canaanite territory, during the MB II, $r = 0.0014$-0.0016, as described below, (iii) along the period of 1533-1800C.E., *r* is estimated as 0.0021 (Baki 1992: 336),[9] and for the modern era, $r = 0.014$.[10]

3. Selecting the final annual growth factor for the mature diachronic model: averaging all relevant results of *r* attained in different works having similar social, economic, and political conditions to that of the Iron Age I.

7.5 Demographic Results and Error Sensitivity

(a) The logarithmic approach:

The logarithmic model used to determine population growth is:

$$Pt = \frac{K}{1 + \left(\frac{K - Po}{Po}\right)e^{-rt}} \quad \text{Eq. A1}$$

Where, *Pt* is the population at time *t*, *K* is the carrying capacity related to the maximum population size available for a certain area, *Po* is the initial population of that area, *r* is the rate of growth per year and *t* is the time span in years.

Rearranging the above equation leads:

$$r = -\frac{1}{t}\left\{\ln\left(\frac{K-Pt}{Pt\left(\frac{K-Po}{Po}\right)}\right)\right\}\text{Eq. A2}$$

$$Po = \frac{Pt \cdot K \cdot e^{-rt}}{K - Pt + Pt \cdot e^{-rt}} \quad \text{Eq. A3}$$

Following Broshi and Gophna (1986), *r* is 180 years' time, from the end of the MB IIA up to the MB IIB, as shown in Table 1:

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[7]It would be even preferable to select a series of successive "errors" and to learn more about the interrelations between them and the "population correction" tendencies.

[8]The Early Bronze II-III is the first time in the history of the Southern Levant in which settlement demographics can be satisfactorily estimated (Broshi and Gophna 1984: 41). Unfortunately, their result refers to "several generations after the beginning of the EB III, ca. 2600 B.C.E.", and no clue is given to the beginning of this period. Therefore, the calculation of *r* is impossible in this case. In the following period, the MB I, a complete destruction of the urban centers occurred and thus this period is also irrelevant for the *r* calculation. The next period, the MB IIA- IIB (2000-1560 B.C.E.) is the second urban period characterized by a new type of settlement: the large rampart. It is also important to add that in this period the Lowlands are stable, characterized by both urban and rural demographic patterns (Finkelstein 1992b: 140, Table 1).

[9] The estimated population is 145.000 in 1533 CE and 275.000 in 1800 CE.

[10]http://www.cbs.gov.il/publications13/rep_06/pdf/intro4_h.pdf

Age	MB IIA	MB IIB
Period (B.C.E.)	2000-1750	1750-1570
Evaluated period (B.C.E.)	1760	1580
Total duration (years)	180	

Table 1: The periods used for the rate of growth (r) calculation

Ignoring the modern era, the maximum population size attained in Eretz Israel occurred during the Byzantine period when the population reached 1 million people (Broshi 1986). Using the numerical values of Pt and Po reported by Broshi and Gophna (1986) facilitates the calculation of the rate of growth, r, as shown in Table 2:

K	t	Pt	Po	r
1,000,000	180	138,000	106,500	0.0016
Broshi 1986: 49	Table 1	Broshi and Gophna 1986: 86-87		Eq. A2

Table 2: Evaluation of the rate of growth (r) for the logarithmic model

Using Eq. 1 and Table 3 and Table 4, it is possible to determine their intersection on the Iron Age I line. Here the size increase is solely attributed to a natural growth and positive or negative immigration may be ignored. The natural growth from the LB IIB to the Iron Age I and the extrapolated value of the Iron Age I as calculated from the Iron Age II are shown in Table 6 and Table 7, respectively.

K	Po	r	t	Pt
260,000	34,000	0.0016	200	45,000
The relative K for the Shephelah and the coastal plan Broshi 1986: 49; Broshi and Gophna 1986: 42	Finkelstein 2000: 169	Table 2	From: 1210 B.C.E. Up to: 1010 B.C.E. Finkelstein 1996: 227	Eq. A1

Table 3: Extrapolated population of Iron Age I evaluated by the logarithmic model, starting from the LB IIB

K	Pt	r	t	Po
260,000	97,000	0.0016	270	73,000
The relative K for the Shephelah and the Coastal Plan Broshi 1986: 49; Broshi and Gophna 1986: 42	Broshi and Finkelstein 1992: 54 (Including: the Shephelah, Philistia and Gaza region)	Table 2	From: 1010 B.C.E. Finkelstein 1996: 227 Up to: 740 B.C.E. Broshi and Finkelstein 1992: 47	Eq. A3

Table 4: Extrapolated population of Iron Age I evaluated by the logarithmic model, starting from the Iron Age II.

In the following, Eq. A3 is being used to reconstruct the population of the Iron Age I, backwards from the initial point of the Iron Age II.

(b) The exponential approach:

In the following discussion the same process will be executed by using the exponential model described in Eq. A4 while the annual growth rate r will be calculated by Eq. A5.

$$Pt = Po \cdot e^{rt} \qquad \text{Eq. A4}$$
$$r = \frac{1}{t}[Ln\,(Pt) - Ln\,(Po)] \qquad \text{Eq. A5}$$

t	Pt	Po	r
180	138,000	106,500	0.0014
Table 1	Broshi and Gophna 1986: 86-87		Eq. A5

Table 5: Evaluation of the rate of growth (r) for the exponential model

Po	r	t	Pt
34,000	0.0014	200	45,000
Finkelstein 2000: 109	Table 5	From: 1210 B.C.E. Up to: 1010 B.C.E. Finkelstein 1996: 227	Eq. A4

Table 6: Extrapolated population of Iron Age I evaluated by the exponential model, starting from the LB IIB.

Pt	r	T	Po
97,000	-0.0014	270	67,000
Broshi and Finkelstein 1992: 54 (Including: the Shephelah, Philistia and Gaza region)	Table 5 (negative sign)	From: 740 B.C.E. Broshi and Finkelstein 1992: 47 Up to: 1010 B.C.E. Finkelstein 1996: 227	Eq. A4

Table 7: Extrapolated population of Iron Age I evaluated by the exponential model, starting from the Iron Age II

(c) Error sensitivity

Broshi and Gophna (1986: 86-87) have suggested an assessment of 20% for the error of the yet undiscovered settled areas. For similarity purposes, demographic estimations of up to 20% accumulated error are shown in Figure 2. The sensitivity of r on the local and non-local populations is shown in Figure 3 for a range of error between +10% and -10%.

It is emphasized that in contrast to the synchronic approach in which a simple linear relation between the built-up error and the size of population exists, in the diachronic model the results are much more complex: (i) the relations between the "error" and the "population" are neither simple nor linear, while

(ii) the same defined error can cause different influence on the estimation of local and the non-local populations (Figure 2), and, (iii) the same defined error can lead to local population increase but to a non-local population decrease (Figure 3).
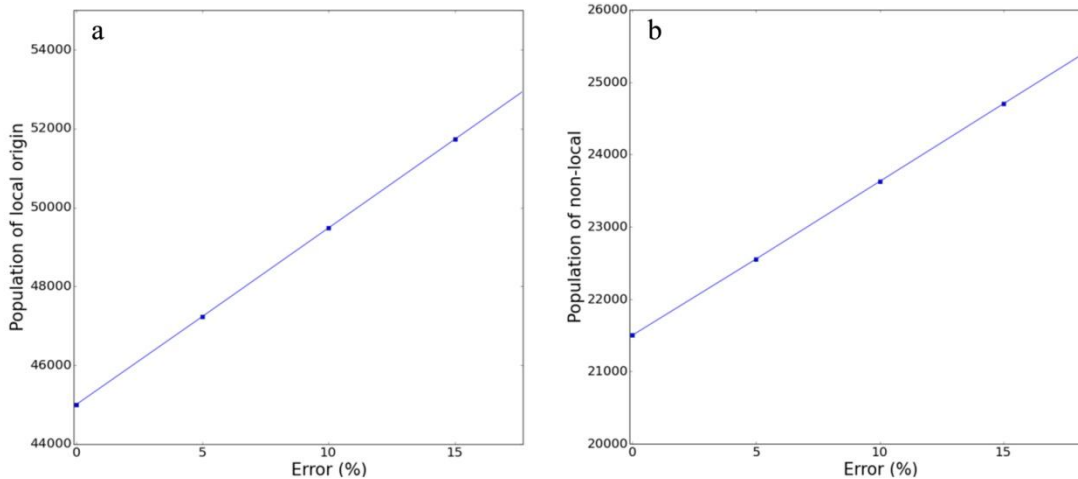

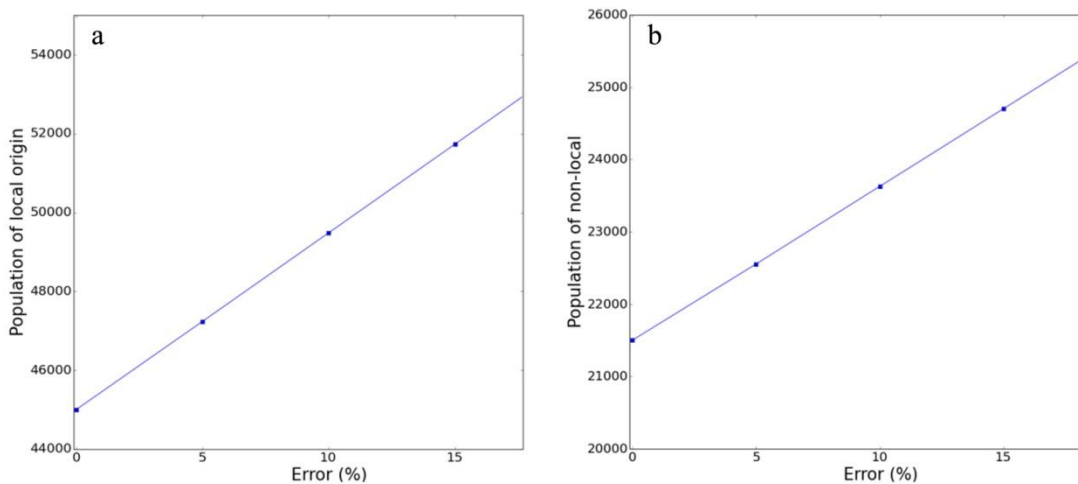**Figure 2: The sensitivity of the built-up error on (a) local and (b) non-local populations**

Figure 3: The sensitivity of *r* on (a) local and (b) non-local populations

8. Acknowledgements

9. References

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