Mediterranean Archaeology and Archaeometry, Vol. 17, No 3, pp. 97-119

DOI: 10.5281/zenodo.1005494

THE SOURCE OF INSPIRATION OF THE PLAN OF THE NABATAEAN MANSION AT AZ-ZANTUR IV IN PETRA: A SPACE SYNTAX APPROACH

Saad Twaissi

Department of History and Archaeology, United Arab Emirates University, P.O.BOX 15551, Al-Ain, United Arab Emirates (saad.twaissi@uaeu.ac.ae)
&
Department of Archaeology, Al-Hussein Bin Talal University, P.O.BOX 20, Maan, Jordan

Received: 08/08/2017
Accepted: 29/09/2017

ABSTRACT

The Nabataean Mansion at az-Zantur in Petra is one of the most elaborated architectural monuments has so far been discovered, and still among the few excavated Nabataean domestic architecture in the region. It covers a large area (1200m in area), and was richly decorated with mosaic, opus sectile, fresco and molded stucco. The date of its first two phases has been established on stratigraphic sequence of pottery, coins and cross-cultural evidence to the Nabataean period of the first century AD. The origin of the plan of this mansion, however, may be considered as a matter of debate. The excavator has suggested that this mansion was inspired by Ptolemaic palatial architecture, e.g the Palazzo delle Collonne in Cyrenaica. Here we argue, on space syntax method (SSM) basis, another possible source for the plan of this mansion i.e. the "Seleucid Governor Palaces'. Space Syntax analysis has wide application in and for archaeology including understanding features of social architecture, functional pattern of buildings, social identity, amongst others. The SSM method will be applied to compare, beside the spatial layout, the syntactic values and genotypes of the Nabataean mansion at az-Zantur-Petra with other palatial architecture in the Hellenistic Near East i.e. with the recently discovered Seleucid governor palace in Syria.

KEYWORDS: Nabataean mansion, Petra, Palatial architecture, Seleucid governor palaces, Space Syntax method

1. INTRODUCTION

The rediscovery of Petra in 1812 by Burckhardt (Burckhardt, 1822, 420-433) had opened a new scope of studies in the ancient Near eastern civilizations, *i.e.* the study of the Nabataean civilization which flourished in the southern Levant and Northwest Arabia from 4th century BC to early second century AD, with Petra as its main urban centre. The long history of research on Nabataean civilization, nevertheless, brought very little conclusion on their domestic life and domestic architecture, although classical sources described their houses of the first century BC as luxurious and costly (Strabo, 16.4.20-26). It was until the late 1980s when the Swiss university of Basil start to investigate for evidence on Nabataean domestic architecture. They were successful in discovering a number of villas at the south-western corner of the ancient city centre of Petra, an area locally known as az-Zantur (Kolb and Stucky, 1993; Stucky *et.al*, 1991,1994,1995; Stucky 1995). One of the most magnificent of these elaborated houses was a Nabataean mansion which was excavated in the years 1996-2001 at az-Zantur IV (Kolb *et.al.*, 1997; Kolb and Keller, 2002; Kolb 2007)

Excavations revealed a 1200m^2 mansion (Fig.1) with three phases of occupation: phase I dated from the early first century AD; phase II dated to late first century/second century AD, this phase being represented by minor alterations and additions to the interior decoration and some architectural features. The last phase dated to the late Roman period and ending with the earthquake of 363 AD (Kolb and Keller, 2001, 311). What is of concern here are the first two phases. The discovery of this mansion has led to a new line of Nabataean studies, *i.e.* the Nabataean urban and domestic life as well as Nabataean domestic architecture. One of the main research issues attached with this mansion is the origin of its plan. The excavator has, in several publications, concluded that: "the Nabataean mansion of az-Zantur IV must be seen in conjunction with Ptolemaic prototypes, which themselves were inspired by Macedonian architecture" (Kolb *et al* 1999: 266; Kolb, 2001, 439 ff, 2007,168). It is the aim of this paper, however, to support another source of inspiration or the origin of the plan of this mansion: that the origin of this mansion should be found in the Seleucid governor palaces. The argument is based on new method applied in the study of domestic architecture in archaeology *i.e.* the space syntax analysis. It will bring to the attention the close similarities in the spatial layout and syntactic values of the recently discovered Seleucid governor palace at Jebel Khalid on the Euphrates in Syria (henceforth 'Jebel Khalid palace') with the Nabataean mansion at ez-Zantur IV in Petra (henceforth 'the Nabataean mansion'), supported by more numerical syntactic analysis for both palaces.

2. DESCRIPTION OF THE BUILDINGS CONCERNED

2.1. The Nabataean Mansion

This mansion covers an area of about 1200m^2 , and it is of square-like plan with main entrance opened in the middle of the northern wall (Fig.1). Its exterior façade was richly decorated with painted stucco and block relief sculpture of Nabataean deities. The remains of this decoration suggest that it was decorated with Doric entablature (Kolb and Keller 2001: 312-315). The main entrance open onto courtyard (no.28 Fig. 1) (Kolb and Keller 2001: 315), which forms the main space through which the different parts of the mansion communicated (Kolb and Keller 2000: 360-361). To the south it is connected with a small, narrow room (room 20, Fig. 1) (Kolb and Keller 2000: 360). To the east, it is connected with a long narrow, corridor; 14m x 2.3m (no.25. Fig.1) (Kolb and Keller 2001: 316), which leads to the reception/guest sector in the central part of the mansion, and open to the eastern sector through various doors, and through corridor 23 it communicates with the private sector of the householders. This corridor was separated by a door from corridor 43 at the south end (Kolb and Keller 2000, 360-361).

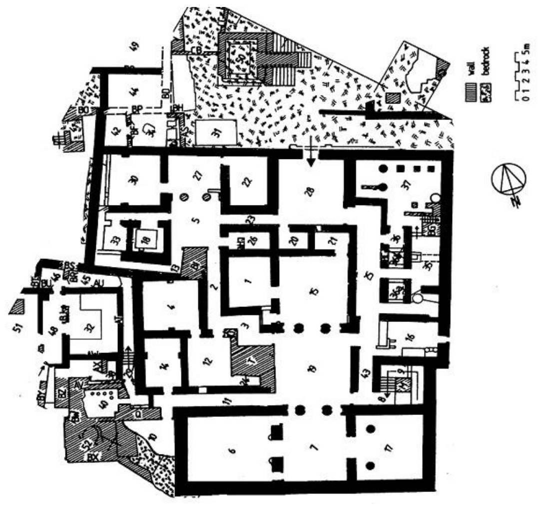

Figure 1:Plan of the Nabataean mansion in Petra (adopted from Kolb and Keller, 2002, 280, fig.1)

The central part, which is represented by halls 15 and 19 serves as the reception/guest sector (Kolb and Keller 2000: 256) and ends with exedra 7 (Kolb *et al* 1999, 264) which is flanked by two banqueting rooms (17 and 6) (Kolb *et al* 1998: 260) (Fig.1). Excavations in the debris of this room revealed a huge number of gilded and painted stucco fragments (Kolb and Keller 2001: 319), attesting to the very luxurious nature of the *mansion* in general and the importance of this room in particular. Room 6 was floored with limestone flags covered by a black-and-white mosaic with geometric pattern of triangles and squares (Kolb *et al* 1998: 260-262). Room 1 opens onto hall 15 through a door, and was lavishly decorated in architectural style (Kolb *et al* 1997: 234-240; 1998: 264-265).

The householder's/private sector dominates the north-western part of the mansion (Kolb and Keller 2000: 256) and is represented by central courtyard 5, surrounded by rooms 26, 18, 27, 22. This sector comprises a kitchen in room 26 (Kolb and Keller 2000: 360), and another exedra-like room, room 27, flanked by two domestic rooms 30 and 28. Courtyard 5 and exedra 27 separated from each other by a " *distylos in antis*" in a similar manner to rooms 19 and 7. Moreover, room 27 was decorated with painted stucco similar to that of room 6 (Kolb and Keller 2000: 364-365).

The south-western part of the mansion accommodates a heated-floor winter living room (room14) with furnace 29 to the west of it. The floor of this room was suspended and supported by tile columns, and was laid with hexagonal tiles and the room ceiling was with a barrel vault (Kolb and Keller 2000: 361-362). The identity of rooms 24 and 12 is not determined, but its relation with room 4 indicates its domestic nature and it may have served as winter living unit. This unit communicated with the private sector through long narrow corridor 2, while the reception/guest sector connected with it through corridor 11.

The private bathhouse dominating the south-western corner of the mansion consisted of a *caldarium* (room 40) with its independent *prefarnium* (room 39) (Kolb and Keller 2002: 287-288).Room 38 served as a fuel storage room for the *prefarniums* of rooms 14 and 40. The other part of the bath consisted of a sweat room (room 52) and a presumed combination of *apodytarium* and *frigidarium* in room 10 (Kolb and Keller 2001: 289).

The eastern wing of the mansion representing the servant sector consisted of courtyard 37 (8.2m X 4m) which served as a supplementary courtyard for the servants of the mansion (Kolb and Keller 2002: 284). Room 16 served as a kitchen linked with the reception/guest sector through the small corridor 43, and presumably rooms 35 and 36 served as storerooms (Kolb and Keller 2001: 316). There was a small staircase between rooms 35 and 36 (Kolb 2007, 167)

It is worth noting that, the building underwent some minor changes during the 4th century AD: the western wall of room 16 was erased to foundations, and a small L-shaped structures of unknown purpose built along the southern wall. The excavator also noted that there was a connecting door between room 16 and room 35 and was blocked up during this phase. Shoddily erected divisions between walls of room 36, and newly installed *taboun* between rooms 35 and 36 as well as a structure of unknown purpose on the east side of room 35 were also dated to this latter phase. These alterations changed the character of the eastern wing.(Kolb and Keller, 2001,316; 2002, 284).

As for the origin of the plan of this mansion, the excavator argues that the prototypes of this mansion can be found in the Ptolemaic palatial architecture, which themselves were inspired by Macedonian architecture (Kolb *et al* 1999: 266; Kolb, 2001, 439 ff, 2007,168). He draw this conclusion on the basis of one architectural feature, which is the layout of the reception/guest sector which consists of central hall with two columns *in antis* flanked by two halls. Nevertheless, this conclusion seems to ignore the general layout of the mansion.

Here the author would argue for a more Near Eastern model for this mansion, mainly from the Seleucid sphere of the Hellenistic world. It is known that the Seleucids took over the palaces of their precursors, mainly the Achaemenid and other royal palaces in that part of their empire without major alterations, and hence the plan and the layout of the palaces of the Seleucids kings and governors remain of more oriental type, while Greek influence were to be found only in the decoration and the architectural elements (Nielsen 1994: 131). It is the purpose of this paper to show more close similarity in the plan and layout of the Nabataean mansion with Seleucid governor palaces. One perfect example for comparison is the recently discovered Seleucid governor palace at Jebel Khalid on the Euphrates in Syria (Clarke, 2002).

2.2. The Jebel Khalid Palace

This palace was first recorded in 1984 and excavated by the Australian National University in 1992, 1997 and 1999. The excavation has uncovered a Seleucid settlement on the west bank of the Euphrates in North Syria . One of the main discoveries was a governor palace with a total area of about 3200m^2 on the Acropolis of that settlement (Clarke 2002, vii-xi). The building was planned around a colonnaded rectangular central courtyard, 'room 26' with four wings surrounding it (Fig.2). A stylobate was laid on the four sides of this courtyard and the colonnade is Doric in order (Clarke, 2002, 25). The eastern wing includes rooms 13-18. Rooms 13 and 14 were entered via a door and corridor from the colonnade. Room 14 also shows two stands made of stones and baked clay evidently used for fires. It was identified as a washroom with the fireplaces serving to heat water and/or the room. There appears to be no direct access from the kitchen (room 11) into room 13 (latrine), though adjacent kitchens and latrines are standard, with drainage arranged external to the dwelling. There was no any indication for the function of rooms 15 and 17. Room 18 however, seems to have functioned only as a corridor to provide a very private access into room 17 from the colonnade. It is very plausible that room 18 might have also contained a staircase to an upper storey but firm evidence for this is lacking (Clarke, 2002, 40-42).

From the colonnade two lengthy vestibule-type corridor rooms opened, one to the north (room 1), and one to the south (room 23), extending nearly the full length of the colonnade on these sides, allowing immediate access to rooms 3, 11 and 12 on the north wing and to rooms 20 and 21 on the south wing. Essentially, however, these rooms acted as antechambers to the audience and banqueting halls of rooms 12 in the northern wing and room 20 in the southern wing (Clarke, 2002, 25; 32-33). As for the northern vestibule (room 1) the area was subdivided at its western end by a cross wall to create a small area (room 2) which open onto the colonnade (28). Access to room 3, which is an outdoor area for religious rites performance with drum altar in situ, was through room 1(Clarke, 2002, 33). In general, the northern wing consists of a courtyard (room 12) surrounded by eight rooms (rooms 4-11). The mode of decoration and the grand architectural features of room 12 as well as its scale (7.390m x 11.340m) suggests that this was a large reception room suitable for entertainment on a large scale, equipped with a number of storerooms, food preparation rooms and two kitchens on either side (Clarke, 2002, 37-40). Rooms 4, 5 and 6 together formed a storeroom/food preparation/kitchen complex with access into the reception (room 12) via room 5 (Clarke, 2002, 33-34). Two very large *pitho*i were found in situ in Room 8, where a total of 34 clay loom weights stored in a large pot and large number of basalt grinders where found. Their presence means at least that it was an unlikely venue for eating or sleeping, rather a magazine room (Clarke, 2002, 36). One of the functions of room 9 was to store an abundant supply of crockery designed for catering for the entertainment of large numbers (Clarke, 2002, 36). Room 11 was furnished with a rectangular hearth built up against its south wall indicating that, like rooms 5 and 6 on the other side of room 12, it was a further cooking area (Clarke, 2002, 37).

The southern wing consists of a vestibule (room 23) and a major entertainment room (room 20) with two store-rooms and kitchens (rooms 19 and 21) adjacent to either side of it. Its function as its equivalent on the north side, room 1, is to provide a vestibule area to the rooms of the southern wing. Room 19 was entered via room 20 only and was serving as a food preparation and cooking area furnished with raised hearth, similar to the one in room 11(Clarke, 2002, 41-42). Room 21, on the western side of room 20, had a similar function to room 19. Both rooms 19 and 21 were clearly designed to service room 20 which was decorated with two massive Doric columns on a stylobate. Although the room itself had been cleared of contents its function should be similar to that of room 12 in the northern section, *i.e.* large-scale entertainment room or a banqueting hall suitable for symposia and similar ceremonials (Clarke, 2002, 42-43).

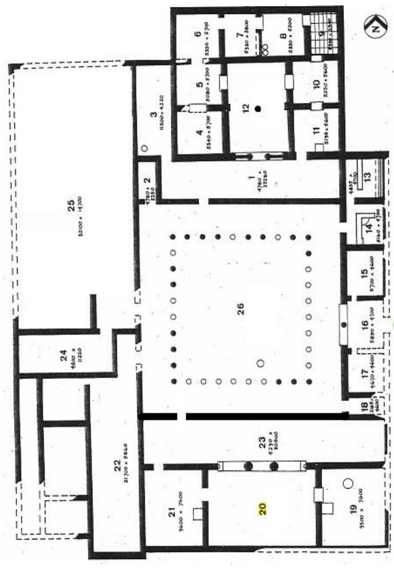

Figure 2: Plan of the Seleucid governor palace at Jebel Khalid, Syria (adopted from Clarke, 2002, 26, fig.1)

The western wing consists of rooms 22 and 24-25. This wing revealed the most intense reuse and reoccupation of the whole complex which make it difficult to understand the precise function of its rooms. In Room 22, however, two official Seleucid seals were found, which best indicating the original use of this room as for official administrative business or for an armory and treasury (Clarke, 2002, 43-45).

3. AN ANALOGY BETWEEN THE NABATAEAN MANSION AND JEBEL KHALID PALACE

Having understanding the plans of both palaces one can see much similarities between both buildings, regardless their scales, in terms of the spatial layout and the function/s of the rooms. The southern wing of both buildings are identical in plan, layout and functions. The eastern wing of both buildings are also identical in the layout with much similarities in functions. The northern part of the Jebel Khalid which is consisting of a courtyard surrounded by rooms with much domestic function (see fig.2, rooms 4-12), is also comparable to that of the Nabataean mansion which was interpreted as a domestic unit (see fig.1. rooms 5,27,22,26,30,18,and 33). One of the main dissimilarity between the buildings is the central colonnaded courtyard in Jebel Khalid, which corresponds in its spatial layout to rooms20-21,26,1,15,19,3,2,and 12 in the Nabataean mansion. It seems that the designer of the az-Zantur favored to have additional rooms in this part of the mansion instead of the central courtyard. It is also suggested that both buildings had been consisting of two stories, and the location of the staircase to the upper story is identical in both cases, *i.e* room 18 in Jebel Khalid Palace (fig.2) and room 8 in the Nabataean mansion (fig.1). Do these similarities between both buildings indicate that the genesis of the Nabataean mansion is to be found in the Seleucid governor palaces? To better demonstrate this issue and to give more logical and mathematical-based support for this idea a Space syntax analysis for both buildings will be presented here and compared

4. SPACE SYNTAX

4.1. Introducing the method

Space Syntax is primarily a method to measure the topological relationships between one space to all other spaces. This method has been developed at the Bartlett Unit for Architectural Studies at the University College of London since late 1970s by Bill Hillier and Julienne Hanson (Hillier and Hanson, 1984).They developed a new way of describing and analyzing the kinds of spatial patterns produced by buildings and towns. They defined space syntax as a set of techniques for quantifying and analyzing the prosperities of architectural and urban space (Hillier and Hanson, 1984). Another definition of space syntax was introduced by Hillier (1999, 165): "*a family of techniques for representing and analyzing spatial layout of all kinds*". This means that it can be used to describe and analyze patterns of architectural space for either single building or group of buildings or large urban space. These techniques has wide implication in many fields. It can be used for morphological analysis of buildings, architectural plans and iteriors, urban areas, and urban plans (Vrusho and Yunnitsyna, 2016; Behbahani, 2016). The aim of this technique is to describe different aspects of the relationships between the morphological structure of manmade environments and social structure (Teklenburg *et.al*, 1993, 347). Archaeologists find space syntax an active tool for their research interests "*because it offers an uncomplicated way to quantify spatial relationships that can be used to interpret or infer social interaction*"*(*Van Dyke ,1999, 461), and it has been used in a wide range in archaeological research projects since it mainly deals with architecture and urban space which is of main interests of archaeology (Ferguson, 1996; Fladd, 2017). In archaeology space syntax was used to understand features of social structures of the ancient buildings or the settlement (Foster 1989), and even social identity (Grahame, 2000). It can also be employed to understand the sources of architectural types (Hillier *et.al*, 1987; Bafna, 2012). This method also employed by archaeologists to study prehistoric settlement architecture (Cutting, 2003), and to investigate economic aspects of historical settlements (Craane, 2009). Other archaeological projects adopted the method of space syntax to analyze urban space of ancient cities (Weilguni, 2011; Stöger 2011; 2015). This method also used in archaeology to decipher function/s of buildings and their social contexts (Nevadomsky *et.al*, 2014); it is also used to understand social change through analysis of changes in architecture of ancient societies (Reyman, 1996).

4.2. The Method

There are two basic measures in space syntax analysis which forms the fundamentals of other spatial measurements. These are the measurements of symmetry/asymmetry and distributedness/non-distributedness. These measures indicate whether the space is integrated with or segregated from other spaces in the system, i.e. distributed configuration means that there is no just single space control the access to the others, but there are more than one route of access among spaces. The contrary (non-distributed configuration) means there is only one route to access a space from another. The overall meaning of these measures is that symmetric and distributed space indicates spatial integration, while asymmetric and nondistributed space indicates spatial segregation (Hillier and Hanson, 1984[2001], 143-148). These are demonstrated through scoring two main syntactic indicators, which are the Relative Asymmetry (RA) and the Real Relative Asymmetry (RRA) values of the space. The relative asymmetry value can be calculated "*by working out the mean depth of the system from the space by assigning a depth value to each space according to how many spaces it is away from the original space, summing these values and dividing by the number of spaces in the system less one (the original) space*" (Hillier and Hanson, 1984[2001]: 108). After calculating the mean depth of the space, its relative asymmetry value can be calculated by the following equation:

$$RA = 2(MD-1)/ K-2$$

Where:

MD: the mean depth of the space

The MD is calculated as MD= Total depth/K-1

K: the number of spaces in the system.

If we to compare between systems of different sizes then the real relative asymmetry (RRA), which is a value designed to compensate for size differences, should be calculated. This value (RRA) can be calculated by dividing the relative asymmetry value of the space (RA) by the D-value for K spaces in the system (RA/D-value) (Hillier and Hanson, 1984[2001]: 109-113). The D-value of the system, according to the whole number of spaces integrated in that system was given by Hiller and Hanson (Hillier and Hanson 1984[2001]: 112. table 3). The implication of these values is that, for the RA value it ranges between zero and one and the lower the value is the more accessible and more symmetric the space in relation to the whole system, and the reverse indicates little accessibility and more asymmetric the space in relation to the whole system. The RRA value nevertheless, ranges between zero and infinite and have the same implication of RA. In addition, values of 0.4 to 0.6 indicate that the system is strongly integrated and symmetric, whereas values tending to 1 and over will be more segregated and asymmetric (see Hillier and Hanson 1984 [2001]: 113).

The first and fundamental step in beginning the analysis is to work out the mean depth of the system from the space to be measured and this can be illustrated by what is called the Gamma analysis/map (Hillier and Hanson 1984 [2001]: 147-148). Gamma analysis is the syntactic analysis of the interior structures represented by a justified permeability graph based on the 2D floor plan of the building (Hilllier and Hanson, 1984, 143). All the spaces in the system (structure or building) are illustrated as nodes linked by routes of access lined from the entrance, or carrier space (carrier space is the space want to be measured), to all successively accessible spaces. This will result in a graph depicting the number of levels between the carrier space and the deepest space in the system. Then, a depth value is assigned to each space based on its shortest route of access from the carrier space. Spaces that are one space away from the carrier space receive a value of 1,spaces that are two spaces away receive a value of 2, and so on. Spaces of depth value of 7, for example, means that a person has to cross 6 spaces before reaching it. Based on the Gamma graph one can assign a depth value for each space as well as the number of spaces at each depth level. Then the total depth value of the whole system from the root is calculated by summing up the multiplication of each depth level with the number of spaces at that level. For example, in the plan proposed in figure 3 there are 14 spaces in the system plus 1 (the outside). The Gamma map of this system (Fig.4) shows that there is 1 space at depth level of 1; 4 spaces at depth level of 2; 4 spaces at depth level of 3; 3 spaces at depth level of 4and 2 spaces at depth level of 5. The total depth value of the system then calculated as : (1x1) + (2x4) + (3x4) + (4x3) + (5x2) = 1+8+12+12+10. This means that the total Depth Value of the system is 43. All other calculations for the carrier space will be based on this value. In this example, the Mean Depth value (MD) is calculated as: 43/15-1 which is 3. 07. The Relative Asymmetry value (RA) then calculated as 2(MD-1)/K-2, *i.e.* 2(3.07-1)/15-2. Then RA= 4.14/13, *i.e.* RA=0.318. According to Hillier and Hanson (1984: 112, table 3) the D-value of a 15 spaces system is 0.259. Then for our example the Real Relative Asymmetry (RRA) of the system from outside is calculated as RA/D- value of K, *i.e.* 0.318/0.259=1.2277.

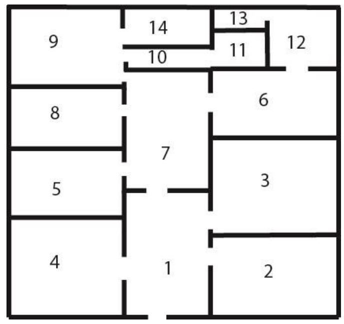

Figure 3: a proposed plan of a building

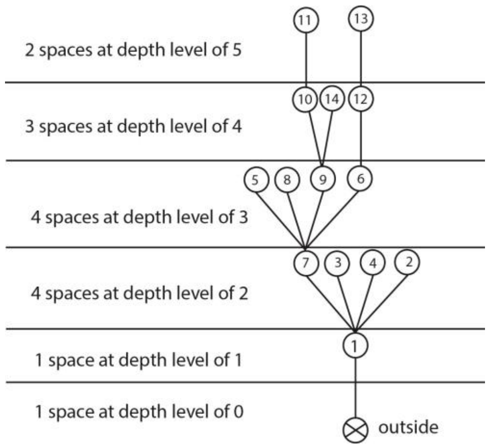

Figure 4: Gamma map from outside for the proposed plan

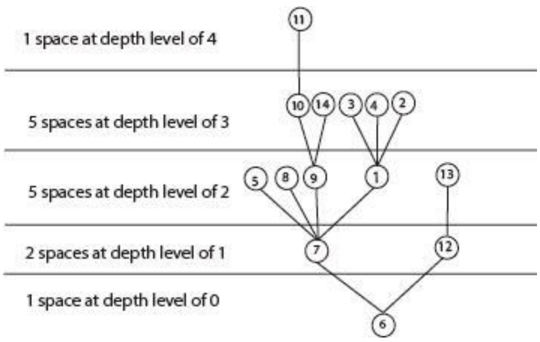

Figure 5: Gamma map for room 6 in the proposed plan excluding outside

Same process should be followed to measure other spaces. Space under measure become the carrier space and in this case the outside space can be excluded. For the same example if we want to measure space 6 then the justified Gama graph will be as in figure 5 with space 6 as carrier, then other measurement will be calculated the same way explained above but considering the D-value of 14 spaces because the outside is excluded. Each space in the system then can be measured following the same steps. Finally, for further illustration for the integration of the space within the same system (building etc) is the integration value (IV). This value reflects the extent to which that space organizes access and movement within that system. The IV is calculated for each space and Higher integration values of spaces indicate that the space is less deep on average from all other nodes which means that it is more integrated into the system. The IV is measured as the inverse of RRA i.e. 1/RRA (Bafna, 2003, 21)

5. APPLICATION ON A CASE STUDY

As mentioned, the purpose of this paper a space syntaxe-based argument on the possible origin of the plan of the Nabataean mansion in the Seleucid governor palaces. For methodological reason it is important here to show what is considered as space in space syntax. Because what is considered by archaeologist as a single spatial unit might be considered as more than one space in space syntax methodology. In space syntax a space is understood as an area in the shape of a convex polygon, with boundary, in which all points are equally visible to each other (Hillier and Hanson, 1984, 772-77; 147). For methodological reasons new spaces were added to the published plans of our case study (figs.6-7). These are spaces (3a, 15a,18a,35b-d and 36c-e) in the Nabataean mansion in (Fig.6), and spaces (13a, 14a-b and 27-33) in the Seleucid governor palace in Syria (Fig.7). In the case of the Nabataean Mansion the plan also was modified to represents phases 1 and 2 by eliminating the additions of the 4th century AD mainly in the eastern wing of the mansion (Fig.6). All spaces of both buildings were spatially and syntactically analyzed. The prefarnium (rooms 29 and 39) in the Nabataean mansion were, nevertheless, excluded from the analysis because it is applicable in space syntax to exclude spaces that are without a social activity (Ostwald and Dawes, 2011). Both were analyzed from outside to set up the initial Gamma map of the buildings (Fig. 8a-b) from which Gamma maps for all other spaces were derived excluding the outside (See APPENDIX at the end, Figs.9-18) The syntactic measurements of each space include Depth (D), Mean Depth (MD), Relative Asymmetry (RA), Real Relative Asymmetry (RRA) and the integration value (IV). The result of this analysis is presented in Tables (1-2) bellow.

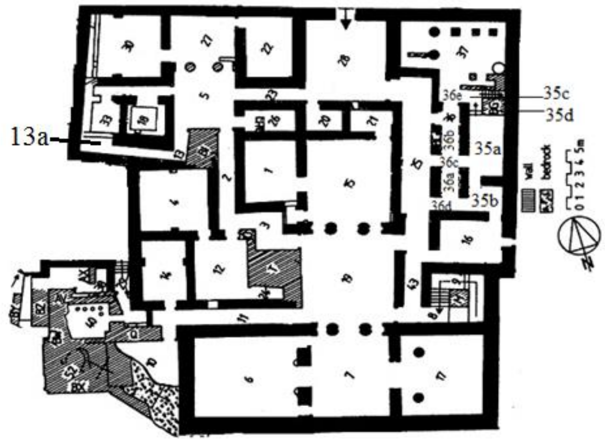

Figure 6: Plan of the Nabataean mansion with new spaces added and excluding additions of the 4th century AD

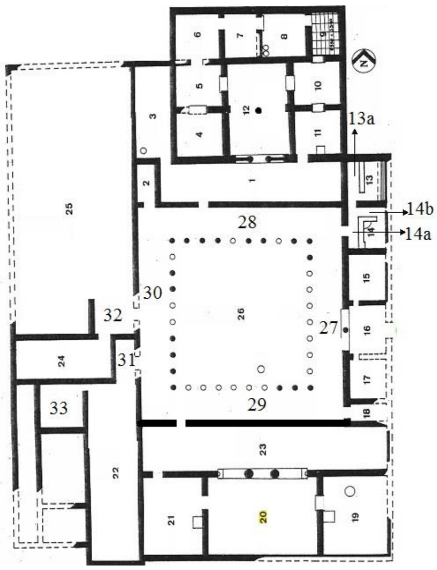

Figure 7: Plan of Jebel Khalid Palace with new spaces added

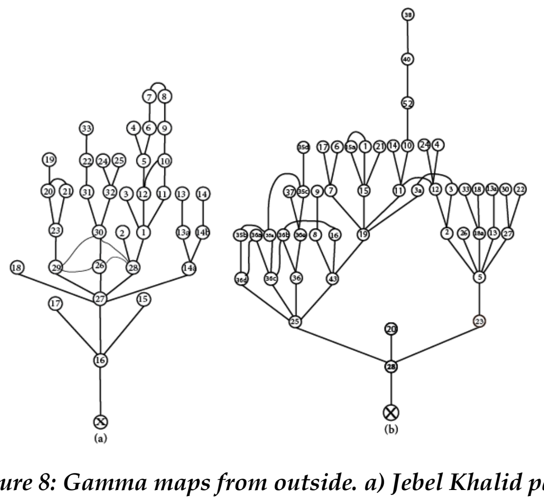

Figure 8: Gamma maps from outside. a) Jebel Khalid palace; b) Nabataean mansion

Table 1. Syntactic values of the Nabataean mansion

sr	Space no.	Space function	D	MD	RA	RRA	IV
1	outside		228	4.653	0.1522	1.1444	0.8737
2	28	Main Entrance courtyard	179	3.7291	0.1161	0.8602	1.1624
3	20		226	4.7083	0.1578	1.1688	0.8555
4	23	corridor	189	3.9375	0.125	0.9259	1.08
5	5	courtyard	183	3.8125	0.1196	0.8865	1.128
6	27		225	4.6875	0.1569	1.1623	0.8603
7	22	domestic	271	5.64583	0.1976	1.4644	0.6828
8	30	domestic	271	5.6458	0.1976	1.4644	0.6828
9	13a	connecting passage	273	5.6875	0.1994	1.4775	0.6768
10	13	passage	227	4.7291	0.1586	1.1754	0.8507
11	33		282	5.875	0.2074	1.5366	0.6507
12	18	small private bathing pool?	282	5.875	0.2074	1.5366	0.6507
13	18a		233	4.8541	0.164	1.2148	0.8231
14	26	kitchen	229	4.7708	0.1604	1.1885	0.8413
15	3	connecting passage	199	4.1458	0.1338	0.9915	1.0084
16	3a	connecting passage	184	3.8333	0.1205	0.893	1.1197
17	2	coridor	191	3.9791	0.1267	0.939	1.0648
18	12	winter living room?	185	3.8541	0.1214	0.8996	1.1115
19	4	winter living room?	232	4.8333	0.1631	1.2083	0.8276
20	24	?	232	4.8333	0.1631	1.2083	0.8276
21	25	corridor	162	3.375	0.101	0.7486	1.3357
22	43	corridor	169	3.5208	0.1072	0.7945	1.2585
23	9	staircase	255	5.3125	0.1835	1.3593	0.7356
24	8	Corridor leading to Staircase	208	4.3333	0.1418	1.0506	0.95175
25	16	kitchen	201	4.1875	0.1356	1.0047	0.9952
26	36	food preparation/service	199	4.1458	0.1338	0.9915	1.0084
27	36d		201	4.1875	0.1356	1.0047	0.9952
28	36b	food preparation/service	239	4.9791	0.1693	1.2542	0.7972
29	36c	food preparation/service	198	4.125	0.1329	0.985	1.0152
30	37	food preparation/service	284	5.9166	0.2092	1.573	0.6356
31	36e	food preparation/service	237	4.9375	0.1675	1.2411	0.8057
32	35d	stair	318	6.625	0.2393	1.773	0.5639
33	35c	stair room	271	5.6458	0.1976	1.4864	0.6727
34	35a	food preparation/storeroom	232	4.8333	0.1631	1.2083	0.8276
35	36a	food preparation/storeroom	240	5	0.1702	1.2608	0.7931
36	35b	food preparation/storeroom	216	4.5	0.1489	1.1032	0.9064
37	19	reception	161	3.3541	0.1001	0.742	1.3476
38	6	banqueting	252	5.25	0.1808	1.3396	0.7464
39	17	banqueting/ensemble room	252	5.25	0.1808	1.3396	0.7464
40	7	reception	205	4.2708	0.1391	1.0309	0.9699
41	1		243	5.0625	0.1728	1.2997	0.7693
42	15a		249	5.1875	0.1781	1.3199	1.3199
43	15	reception courtyard	203	4.2291	0.1374	1.0178	0.9824
44	21		250	5.2083	0.179	1.3265	0.7538
45	11	corridor	171	3.5625	0.109	0.8077	1.238
46	14	winter living room	218	4.5416	0.1507	1.1163	0.8957
47	38	fuel store	347	7.2291	0.265	1.9634	0.5092
48	40	*caldarium*	255	5.3125	0.1835	1.3593	0.7356
49	52	bath sweat room	255	5.3125	0.1835	1.3593	0.7356
50	10	*apodytarium* and *frigidarium*	212	4.4166	0.1453	1.0769	0.9285
-	Mean		228.48	4.7580	0.1598	1.1857	0.8951

Table 2. Syntactic values of Jebel Khalid palace

sr	Space no.	Space function	D	MD	RA	RRA	IV
1	outside		171	4.75	0.2142	1.3392	0.7466
2	16	Main Entrance courtyard	135	3.8571	0.168	1.031	0.9698
3	17	?	169	4.8285	0.2252	1.3816	0.7237
4	15	?	169	4.8285	0.2252	1.3816	0.7237
5	14a	passage	131	3.7428	0.1613	0.9898	1.0102
6	14b	passage	163	4.6571	0.2151	1.3197	0.7576
7	14	washroom	197	5.6285	0.2722	1.6703	0.5986
8	27	corridor	105	3	0.1176	0.7217	1.3855
9	13a	passage	163	4.6571	0.2151	1.3197	0.7576

10	13	latrine	197	5.6285	0.2722	1.6703	0.5986
11	18	corridor/staircase	139	3.9714	0.1747	1.0723	0.9325
12	19	preparation and cooking area	209	5.9714	0.2924	1.794	0.5573
13	20	banqueting hall	175	5	0.2352	1.4435	0.6927
14	21		166	4.7428	0.2201	1.3507	0.7403
15	23	vestibule corridor	144	4.1142	0.1831	1.1238	0.8897
16	29	corridor	116	3.3142	0.1361	0.8351	1.1973
17	30	corridor	111	3.1714	0.1277	0.7836	1.2761
18	32		141	4.0285	0.1781	1.0929	1.0929
19	25		175	5	0.2352	1.4435	0.6927
20	24		175	5	0.2352	1.4435	0.6927
21	33		207	5.9142	0.289	1.7734	0.5638
22	22	armory and treasury	173	4.9428	0.2319	1.4229	0.7027
23	31		141	4.0285	0.1781	1.0929	1.0929
24	28	corridor	100	2.8571	0.1092	0.6702	1.492
25	26	central reception courtyard	107	3.0571	0.121	0.7423	1.347
26	1	vestibule corridor	114	3.2571	0.1327	0.8145	1.2276
27	3	religious performance	148	4.2285	0.1899	1.1651	0.8582
28	2		134	3.8285	0.1663	1.0207	0.9796
29	12	reception/banqueting hall	134	3.8285	0.1663	1.0207	0.9796
30	11	cooking room	141	4.0285	0.1781	1.0929	0.9149
31	10		161	4.6	0.2117	1.2991	0.7697
32	9	crockery storeroom	190	5.4285	0.2605	1.5981	0.6257
33	8	food magazine room	218	6.2285	0.3075	1.8868	0.5299
34	7		218	6.2285	0.3075	1.8868	0.5299
35	6	kitchen	190	5.4285	0.2605	1.5981	0.6257
36	5	food preparation	161	4.6	0.2117	1.2991	0.7697
37	4	storeroom	195	5.5714	0.2689	1.6497	0.6061
Mean			159	4.539140541	0.2079649	1.2767865	0.8554351

6. DISCUSSION

Beside the similarities in architecture and spatial layout between the Nabataean mansion and Jebel Khalid palace, the spatial analysis and the syntactic values derived have also show that both buildings share close syntactic values. The Gamma maps of both buildings from outside (Fig.8) show that in both cases corridors control the access to most spaces and they are located in the second and third depth levels. More gamma maps per se are given in the Appendix. These corridors share very close RRA and IV values (see Tables 1 and 2 to compare spaces 25, 43 and 11 in the Nabataean mansion with spaces 27-30 in Jebel Khalid palace). The central courtyard of Jebel Khalid palace (space 26), which corresponds in its position to spaces 20-21,26,1,15,19,3,24 ,and partially 12 in the Nabataean mansion. The central part of these rooms is 19 which also has an exact equal RRA and IV values to courtyard 26 of Jebel Khalid. In the other hand, the Gamma maps also clearly show that the ring access of spaces (27-30) of Jebel Khalid palace which encompass courtyard 26 also corresponds to that ring access of spaces (28,23,5,2,12,11,19,43 and 25). Spaces which are in the same position and have same function, *e.g* .space 8 of the Nabataean mansion and space 18 of Jebel Khalid palace, also have a semi-exact equal RRA and IV values. Furthermore, the southern wings in both palaces which are corresponding in position and function also have, syntactically, close RRA values (see Tables 1 and 2 to compare spaces 19-21 in Jebel Khalid palace with spaces 6, 7 and 17 in the Nabataean mansion) and both wings also located at the fifth depth level. In general both buildings share close values of Mean depth, Mean RRA and Mean IV (see Tables 1 and 2). Do all these architectural and syntactic similarities mean that both buildings have cultural similarities and share genotypes? For the author, all facts discussed above strongly support the answer "yes", and suggests that both buildings are sharing common background. However, there is another syntactic value should be measured here which could be the final proof for this answer. This value is called "the relativised Difference Factor" (H*). According to Hillier and his colleagues (Hillier *et.al,* 1987, 365) difference in integration values for different spaces in the system is an indication of how culture built in spatial layout. This difference can be numerically measured through what Hillier *et.al* (1987, 365) called as the "Difference Factor" (H) which is 'an entropy-based measure'. For this purpose they offered the following equation:

$$H = -\sum \left[\frac{a}{t} \times ln\left(\frac{a}{t}\right)\right] + \left[\frac{b}{t} \times ln\left(\frac{b}{t}\right)\right] + \left[\frac{c}{t} \times ln\left(\frac{c}{t}\right)\right]$$

Where:

H: is the unrelativised difference factor for the three RRA values (a,b and c)

a: is the minimum RRA value

b: is the mean RRA value

c: is the maximum RRA

t: is the $\sum$a+b+c

ln : is the natural logarithm of any number

Then (H) can be relativised between *ln2* and *ln3* to give a relative Difference factor (H*) between 0 and 2. H* value with 0 is the maximum difference factor or the minimum entropy, and 2 is the minimum difference or maximum entropy. Thus H* is measured by the following equation:

$H* = \frac{H-ln2}{ln3-ln2}$ (Hillier *et.al*, 1987, 365)

Where: H is is the unrelativised difference factor

*ln*2: is the natural algorithmic value of number 2 which is 0.693147

*ln*3: is the natural algorithmic value of number 3 which is 1.098612

(https://www.mathpapa.com/calc/alg).

Values above 1 is indicating weak difference factor while values below 1 tends to be strong difference factor. Hillier and his colleagues, believe that this measure is "*able to express culturally significant typological differences among plans because the two concepts on which they are based have in themselves a kind of intrinsic 'social logic*" (Hillier *et.al*, 1987, 365). The implication is that if there are two or more houses/buildings with similar H* value ± (e.g. 0.77-0.81) then cultural similarities\pattern and genotype is likely exists within the sample (Miana, 2014. 26-27).

As for the Nabataean mansion, with reference to Table 1:

a= 0.7420

b= 1.1857

c= 1.9634

t= 3.8912

then

$$H = -\sum\left[\frac{0.742}{3.8912}\times ln\left(\frac{0.742}{3.8912}\right)\right]+\left[\frac{1.1857}{3.8912}\times \ln\left(\frac{1.1857}{3.8912}\right)\right]+\left[\frac{1.9634}{3.8912}\times \ln\left(\frac{1.9634}{3.8912}\right)\right]$$

H= -∑[0.1906 Xln0.1906]+[0.3047xln0.3047]+[0.5045xln0.5045]

H= -∑[0.1906x-1.657578]+[0.3047x-1.188428]+[0.5045x-0.684187]

H= -∑[-0.3159343668]+[- 0.3621140116]+[-0.3451723414]

H= -[-1.0232207198]

H=1.0232207198

$$H* = \frac{H-ln2}{ln3-ln2}$$

H*= $\frac{1.0232207198-0.693147}{1.098612-0.693147}$ = 0.3300737198/0.405465

Then, **H*= 0.8141**

As for Jebel Khalid Palace, with reference to table 2

a: 0.6702

b: 1.2767

c: 1.8868

t: 3.8337

then

$$H = -\sum\left[\frac{0.6702}{3.8337}\times ln\left(\frac{0.6702}{3.8337}\right)\right]+\left[\frac{1.2767}{3.8337}\times ln\left(\frac{1.2767}{3.8337}\right)\right]+\left[\frac{1.8868}{3.8337}\times ln\left(\frac{1.8868}{3.8337}\right)\right]$$

H= -∑[0.1748 x ln0.1748]+[0.3330 x ln0.3330]+[0.4921 x ln0.4921]

H= -∑[0.1748x-1.744113]+[0.3330x-1.099613]+[0.4921x-0.709073]

H= -∑[-0.3048709524]+[- 0.366171129]+[- 0.3489348233]

H= -[-1.0199769047]

H= 1.0199769047

$$H *= \frac{H - ln2}{ln3 - ln2}$$

$ln2$=0.693147
$ln3$=1.098612

$$H *= \frac{1.0199769047 - 0.693147}{1.098612 - 0.693147}$$

H*=0.3268299047/0.405465

H*=0.8060

Thus, both Nabataean mansion and Jebel Khalid palace have very close H* value (0.8141 and 0.8060 respectively) which means that cultural pattern and genotype do exist.

7. CONCLUSION

This paper has arguing that the origin of the plan of the Nabataean mansion discovered in Petra could be found in the Seleucid governor palaces in the Near East. It has brought to the attention the close architectural similarities between the Nabataean mansion and the newly discovered Seleucid governor palace at Jebel Khalid on the Euphrates in Syria. Beside the traditional comparative method of art history, the author implies a more numerical method to support his hypothesis *i.e.* the space syntax method which now has many implications in new archaeological researches. The syntactic analysis has supported the preliminary notes on the similarities between the plans of the two buildings concerned. A further proof on the origin was supported by the Difference factor value (H*) which indicates a cultural and architectural genotypes exists within the Nabataean Mansion in Petra and the Seleucid governor palace in Syria. Based on these facts the author concludes that there is common "architectural DNA" between the two buildings.

ACKNOWLEDGMENT

The author would like to express his sincere thanks for Al-Hussein Bin Talal University and the Untitled Arab Emirates University, for the former grant him a sabbatical year to fulfill this research paper and the latter offered him a position in the Department of History and Archaeology and full access to the university sources which led this research to a successful conclusion.

REFERENCES

Bafna, S. (2003) Space syntax: a brief introduction to its logic and analytical techniques. *Environmental Behavior*, Vol.35, No.1, pp.17–29

Bafna, S. (2012) Rethinking genotypes: comments on the genotypes in architecture. Response to Julienne Hanson's 'The anatomy of privacy in Architects' London Houses' (1998), *The Journal of Space Syntax*, Vol.3, No.1, pp. 69-80.

Behbahani , P., Gu, N. And Ostwald, M. (2014) Comparing the properties of different space syntax techniques for analysing interiors. In *Across: Architectural Research through to Practice: 48th International Conference of the Architectural Science Association,* F. Madeo and M. Schnabel (eds), Genova, The Architectural Science Association & Genova University Press pp. 683–694

Burckhard , J. (1822) *Travels in Syria and the Holy Land* , London, The Association for Promoting the Discovery of the Interior Parts of Africa, John Murray

Clarke, G. (2002) Introduction. In *Jebel Khalid on the Euphrates: report on excavations 1986-1996*, G.Clarke, P.,Conner, L. Crewe, B. Frohlich, H. Jackson, J. Littleton, C. Nixon, M. O'Hea and D. Steele, (ed), Sydney, Mediterranean Archaeology Supplement 5, pp. VII-XI

Clarke, G. (2002) The governor palace, acropolis. In *Jebel Khalid on the Euphrates: Report on Excavations 1986-1996*, G.Clarke, P.,Conner, L. Crewe, B. Frohlich, H. Jackson, J. Littleton, C. Nixon, M. O'Hea and D. Steele, (ed), Sydney, Mediterranean Archaeology Supplement 5, pp. 25-48

Craane, M. (2009) The medieval urban 'movement economy' using space syntax in the study of medieval towns as exemplified by the town of 's-Hertogenbosch. In *the Netherlands, Proceedings of the 7th International Space Syntax Symposium*, K. Daniel, L. Marcus and J. Steen (ed) Stockholm: KTH, Ref.019, 019:1-0.19:14 (http://www.sss7.org/Proceedings/07%20Urban%20Structures%20and%20Spatial%20Distribution/019_Craane.pdf)

Cutting, M. (2003) The use of spatial analysis to study prehistoric settlement architecture. *Oxford Journal of Archaeology*, Vol. 22, No.1, pp. 1-23.

Van Dyke, Ruth M. 1999, Space syntax analysis at the Chacoan outlier of Guadalupe, *American Antiquity*, Vol. 64, No. 3. pp. 461-473.

Ferguson, T.(1996) *Historic Zuni Architecture and Society: An Archaeological Application of Space Syntax*, Tucson, University of Arizona Press.

Fladd, S.(2017) Social syntax: An approach to spatial modification through the reworking of space syntax for archaeological applications, *Journal of Anthropological Archaeology*, vol. 47, pp. 127-138.

Foster, S. (1989) Analysis of spatial patterns in buildings (access analysis) as an insight into social structure: examples from the Scottish Atlantic Iron Age. *Antiquity,* Vol. 63 (238), pp. 40-50.

Grahame, M. (2000) *Reading Space: Social Interaction and Identity in the Houses of Roman Pompeii. A Syntactical Approach to the Analysis and Interpretation of Build Space.* BAR International Series 886.

Hillier B. (1999) *Space is the Machine: A Configurational Theory of Architecture*, Cambridge, Cambridge University Press.

Hillier, B. and Hanson, J.(1984 [2001]) *The Social Logic of Space*, Cambridge, Cambridge University Press

Hillier, B., Hanson, J. and Graham, H. (1987). Ideas are in things: an application of the space syntax method to discovering house genotypes, *Environment and Planning B: Planning and Design*, Vol.14.No.4, pp. 363-385.

Kolb, B. (2001), A Nabataean mansion at Petra: some reflections on its architecture and interior design, *Studies in the History and Archaeology of Jordan*, Vol. IIV, pp. 437-445

Kolb, B. (2007) Nabataean private architecture. In *The World of the Nabataeans: Volume 2 of the International Conference, The World of the Herods and the Nabataeans, Held at the British Museum, 17-19 April 2001*, K. Politis (ed), Franz Steiner, Verlag, pp. 145-171

Kolb, B., Gorgerat, L., and Graweher, M. (1999) Swiss- Liechtenstein excavations on az-Zantur in Petra 1998, *Annual of the Department of Antiquities of Jordan,* Vol.
XLII, pp. 261-277.

Kolb, B. with Contributions by Keller, D. and Brogli, R. (1997) Swiss- Liechtenstein excavations at az- Zanture in Petra 1996: the seventh season, *Annual of the Department of Antiquities of Jordan* , Vol.XLI, pp. 231-242.

Kolb, B. with Contributions by Keller, D. and Gerber, Y., (1998) Swiss- Liechtenstein excavations at az-Zanture in Petra 1997, *Annual of the Department of Antiquities of Jordan*, Vol.42, pp. 259-277.

Kolb, B. and Keller, D. (2000) Swiss- Liechtenstein excavations at az- Zantur/ Petra: the tenth season*, Annual of the Department of Antiquities of Jordan,* Vol. XLIV, pp. 355- 372.

Kolb, B. and Keller, D. (2001) Swiss-Liechtenstein excavation at az-Zantur/Petra: the eleventh season, *Annual of the Department of Antiquities of Jordan,* Vol. 45, pp. 311-324.

Kolb, B. and Keller, D. (2002) Swiss-Liechtenstein excavation at az-Zantur/Petra: the twelfth season, *Annual of the Department of Antiquities of Jordan,* Vol. 46, 279-293.

Kolb, B. and Stucky, R. (1993) Preliminary report of the Swiss- Liechtenstein Excavations at Ez- Zanture in Petra 1992. The fourth campaign, *Annual of the Department of Antiquities of Jordan,* Vol. XXXVII, pp. 417-425

Maina, J. (2014) Discovering hidden patterns: An overview of space syntax methods in architecture and housing research. *Department of Architecture Seminar Series*, Nigeria, Ahmadu Bello University, pp.18-33

Nevadomsky, J., Lawson,N., and Hazlett, K., (2014) An ethnographic and space syntax analysis of Benin kingdom nobility architecture. *African Archaeological Review*, Vol. 31, No. 1, pp. 59–85

Nielsen, I. (1994) *Hellenistic Palaces Traditional and Renewal*. Studies in Hellenistic Civilisation V, Aarhus, Aarhus University Press.

Ostwald M. and Dawes M. (2011) Axial line analysis revisited: reconsidering its value for architecture. *The international journal of the constructed environment*. Vol., No.3, pp. 219-242

Reyman, J. (1996) *Historic Zuni Architecture and Society. An Archaeological Application of Space Syntax*, Anthropological Papers of the University of Arizona, Tucson, University of Arizona Press

Stöger, H. (2011) *Rethinking Ostia. A Spatial Enquiry Into The Urban Society Of Rome's Imperial Port-Town*, Leiden, Leiden University Press.

Stöger J. (2015) Roman neighborhoods by the numbers: A space syntax view on ancient city quarters and their social life, *The Journal of Space Syntax,* Vol. 6, No.1, pp.61-80.

Strabo, *The Geography.* With English Translation by Horace Leonard Jones. London, William Heireman, and New York, G.P. Putam's sons

Stucky, R. (1995) The Nabataean house and the urbanistic system of the habitation quarter in Petra. *Studies in the History and Archaeology of Jordan* V: 193-198

Stucky, R. *et.al* (1991). Swiss-Liechtenstein excavations at az-Zantur in Petra 1989, the second campaign. *Annual of the Department of Antiquities of Jordan,* Vol. XXXV, pp.251-273

Stucky, R., Gerber, Y., Kolb, B. and Schmid, S. (1994) Swiss-Liechtenstien excavations at az-Zanture in Petra 1993: the fifth campaign, *Annual of the Department of Antiquities of Jordan,* Vol. XXXVIII, pp. 271-287.

Stucky, R., Kolb, B., Schmid, S., Gerber, Y., Bellwald, U. and Jacquat, C. (1995) Swiss-Liechtenstein excavations at az-Zantur in Petra 1994, the sixth campaign,

Annual of the Department of Antiquities of Jordan, Vol. XXXIX, pp. 297-315

Teklenburg, J., Timmermans, H. and Wagenberg, van M. (1993) Space syntax : standardised integration measures and some simulations, *Environment and Planning B: Planning and Design*, Vol. 20, No.3, pp. 347-357.

Weilguni, M. (2011) *Streets, Spaces and Places: Three Pompeiian Movement Axes Analysed,* Sweden, Uppsala University.

Vrusho, B. and Yunnitsyna, A. (2016) Space syntax analysis in the Albanian dwellings, *Scientific Research and Information Technology,* Vol. 6, No. 1, Pp. 95-106.

Websites
https://www.mathpapa.com/calc/alg

Appendix
The Gamma maps of the case study

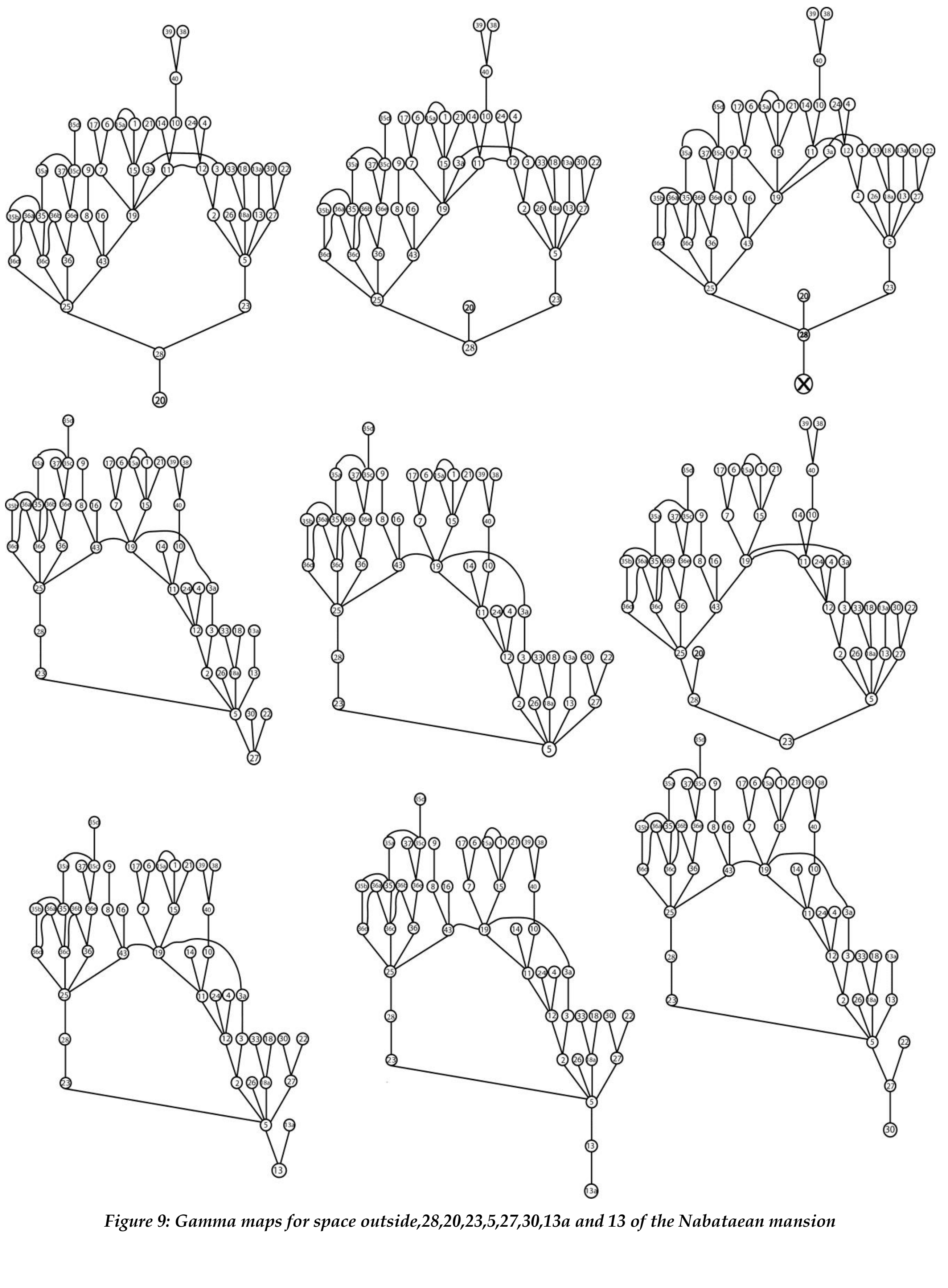

Figure 9: Gamma maps for space outside,28,20,23,5,27,30,13a and 13 of the Nabataean mansion

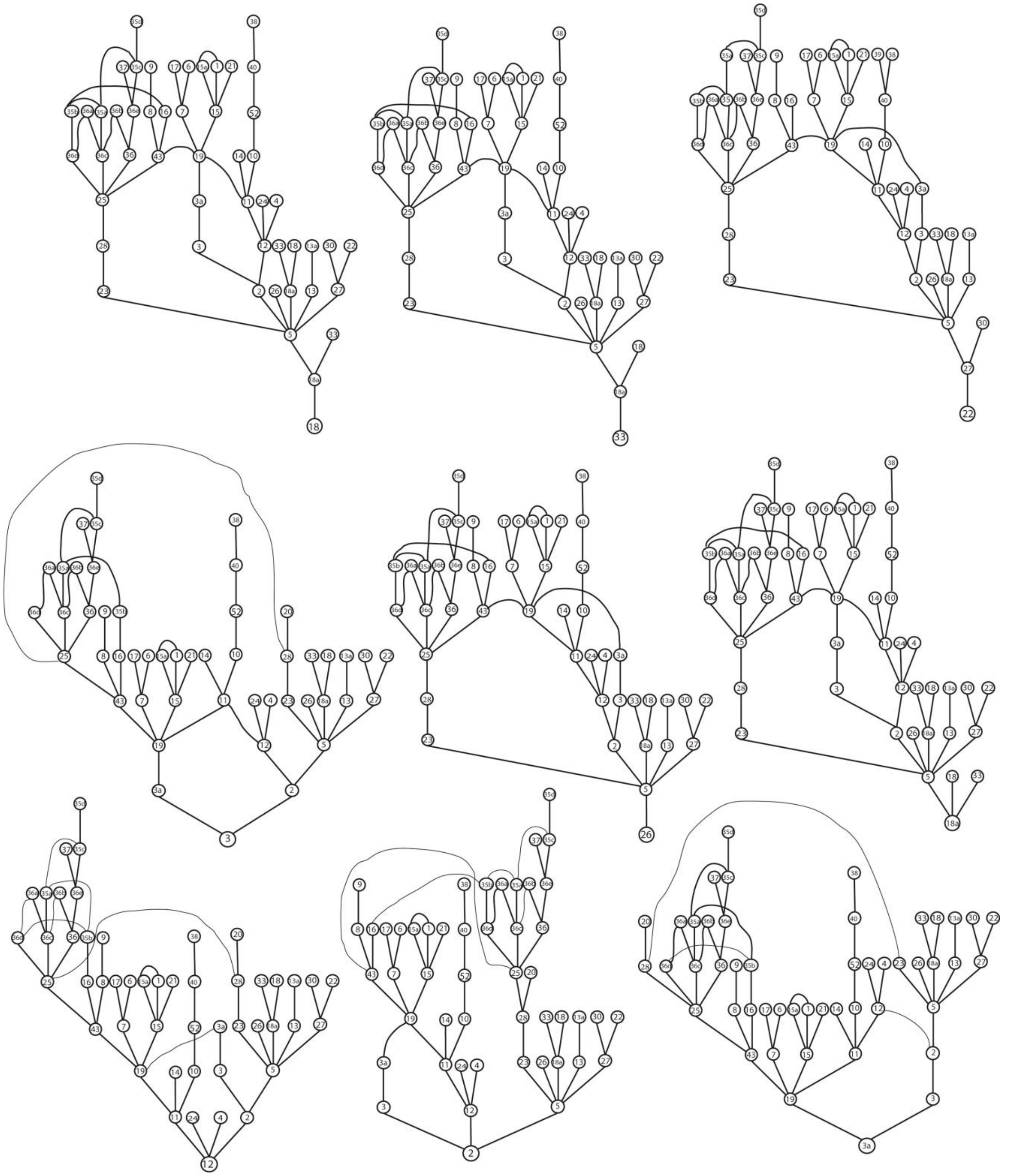

Figure 10: Gamma maps for spaces 22,33,18,18a,26,3,3a,2 and 12 in the Nabataean mansion

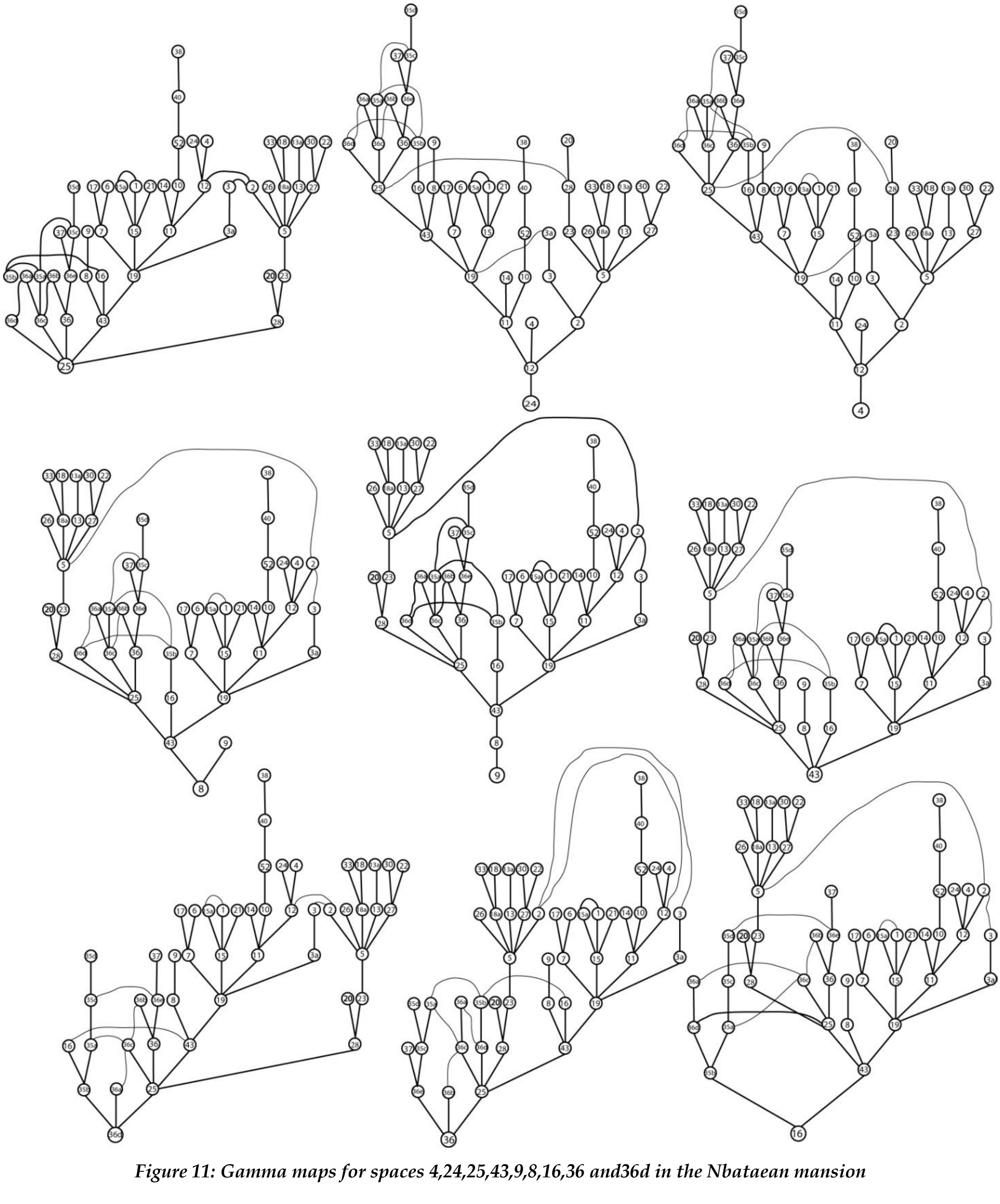

Figure 11: Gamma maps for spaces 4,24,25,43,9,8,16,36 and36d in the Nbataean mansion

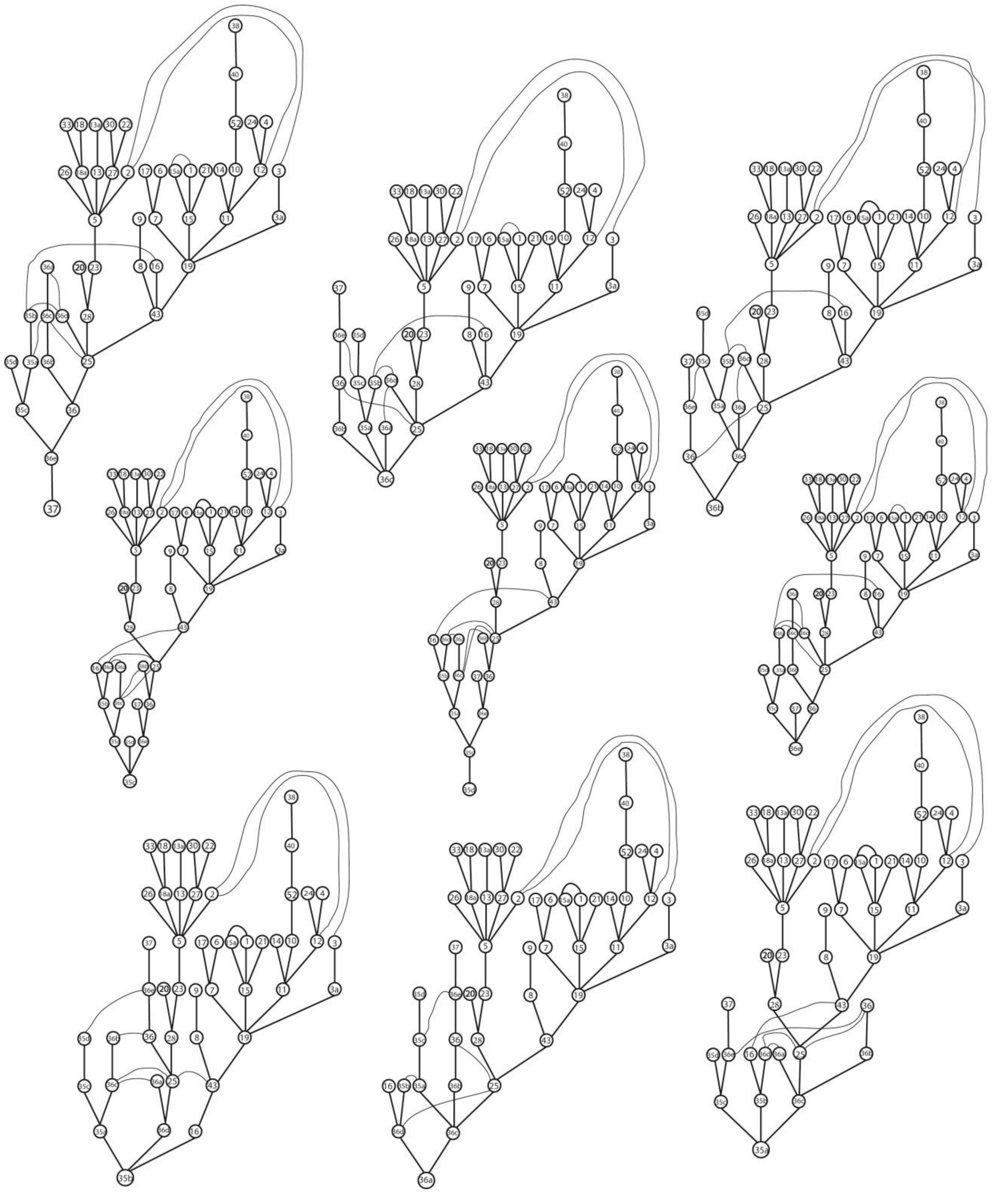

Figure 12: Gamma maps for spaces 36b,36c,3736c,35d35c,35a,36a and 35b in the Nabataean mansion

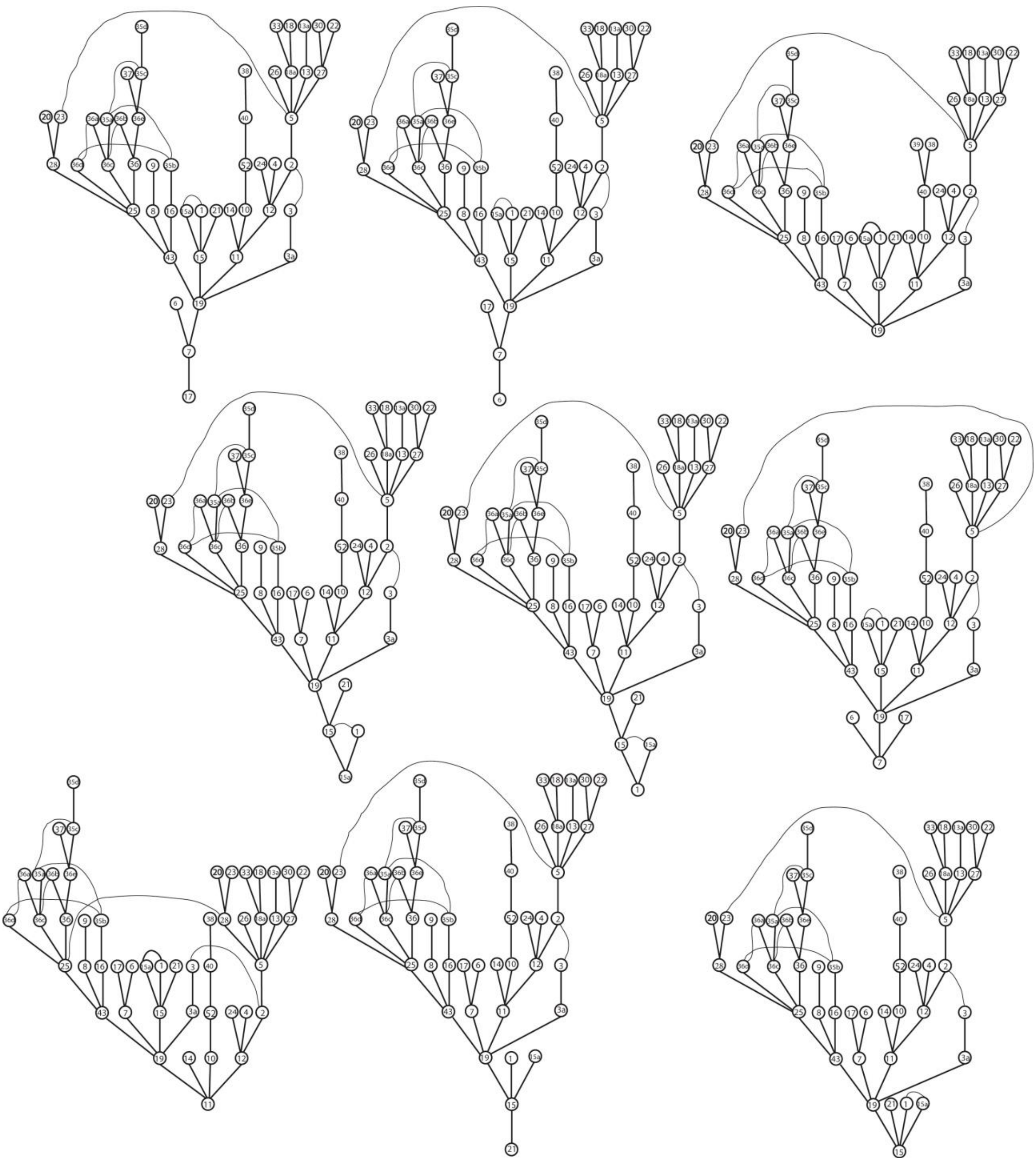

Figure 13: Gamma maps for spaces 19,6,17,7,1,15a,15,21 and 11in the Nabataean mansion

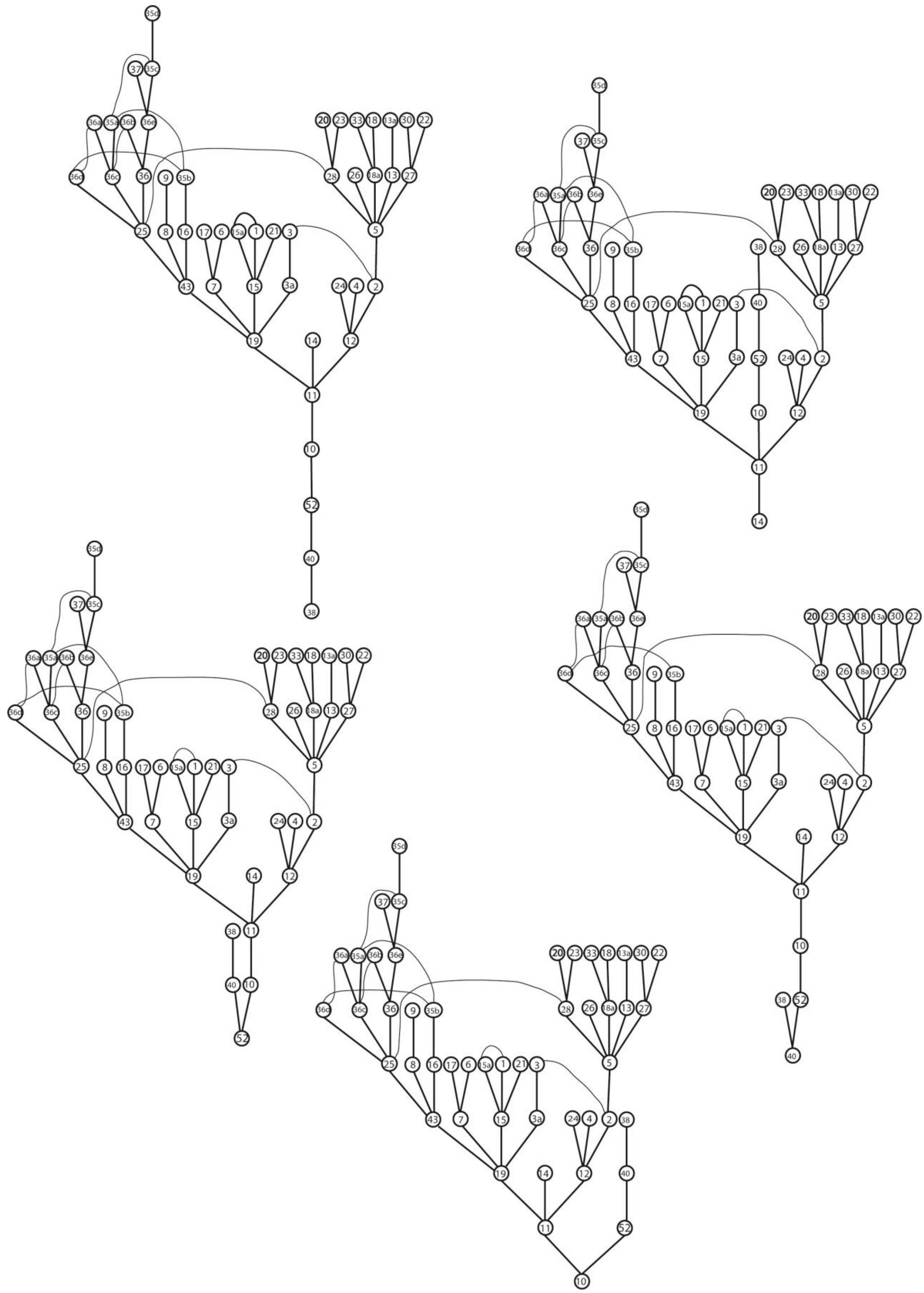

Figure 14: Gamma maps for spaces 14,38,40,52 and10 in the Nabataean mansion

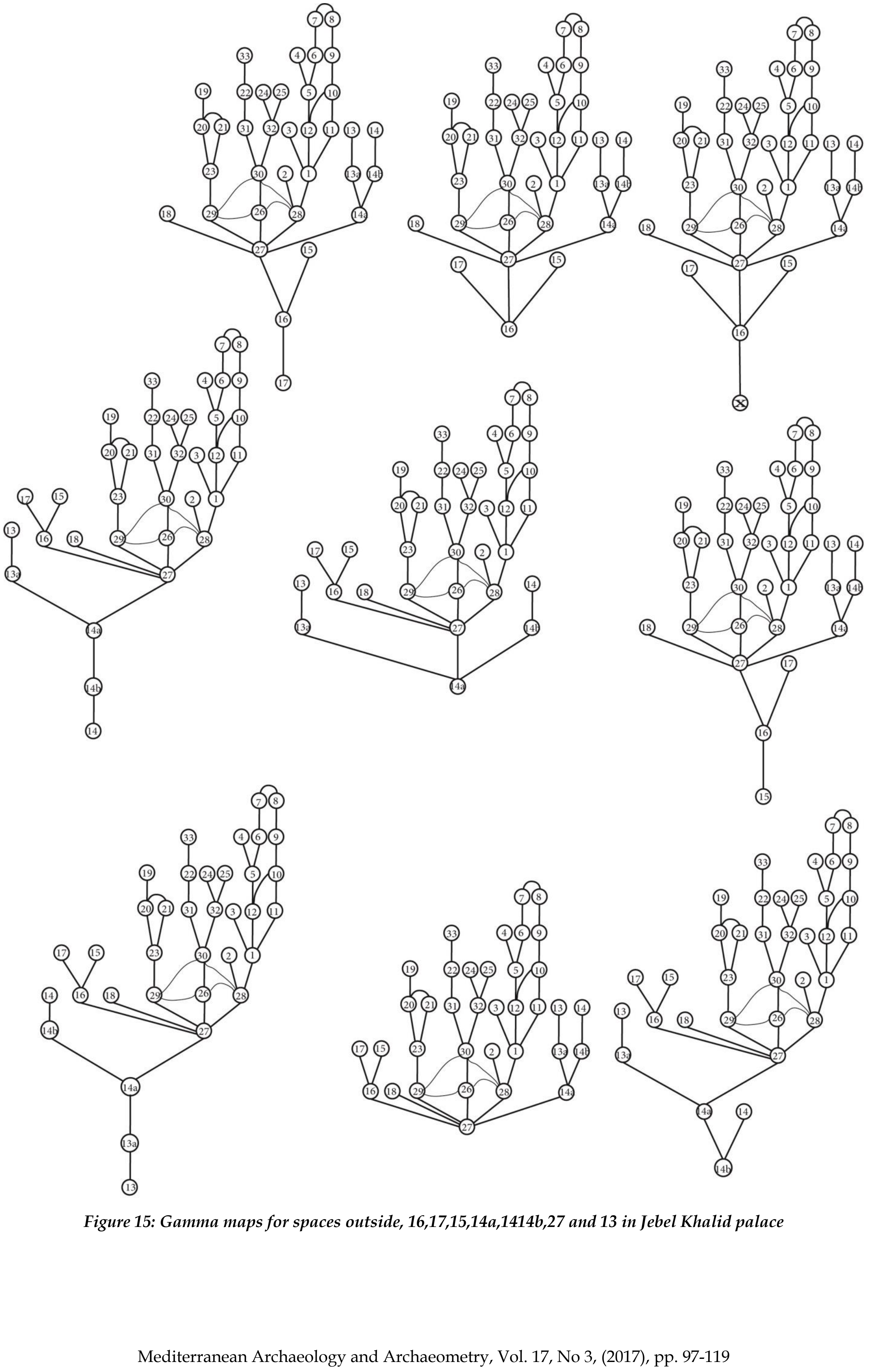

Figure 15: Gamma maps for spaces outside, 16,17,15,14a,1414b,27 and 13 in Jebel Khalid palace

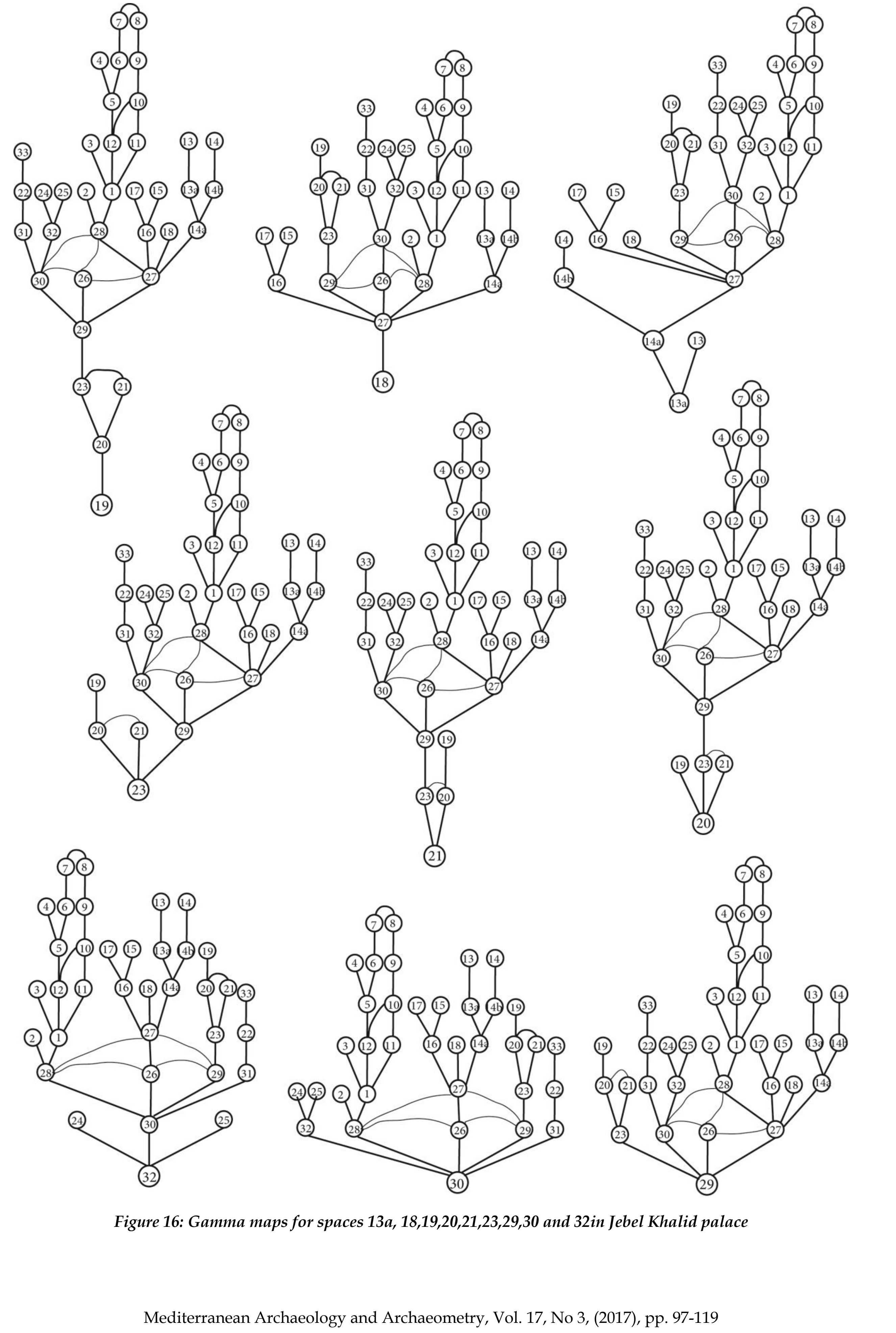

Figure 16: Gamma maps for spaces 13a, 18,19,20,21,23,29,30 and 32in Jebel Khalid palace

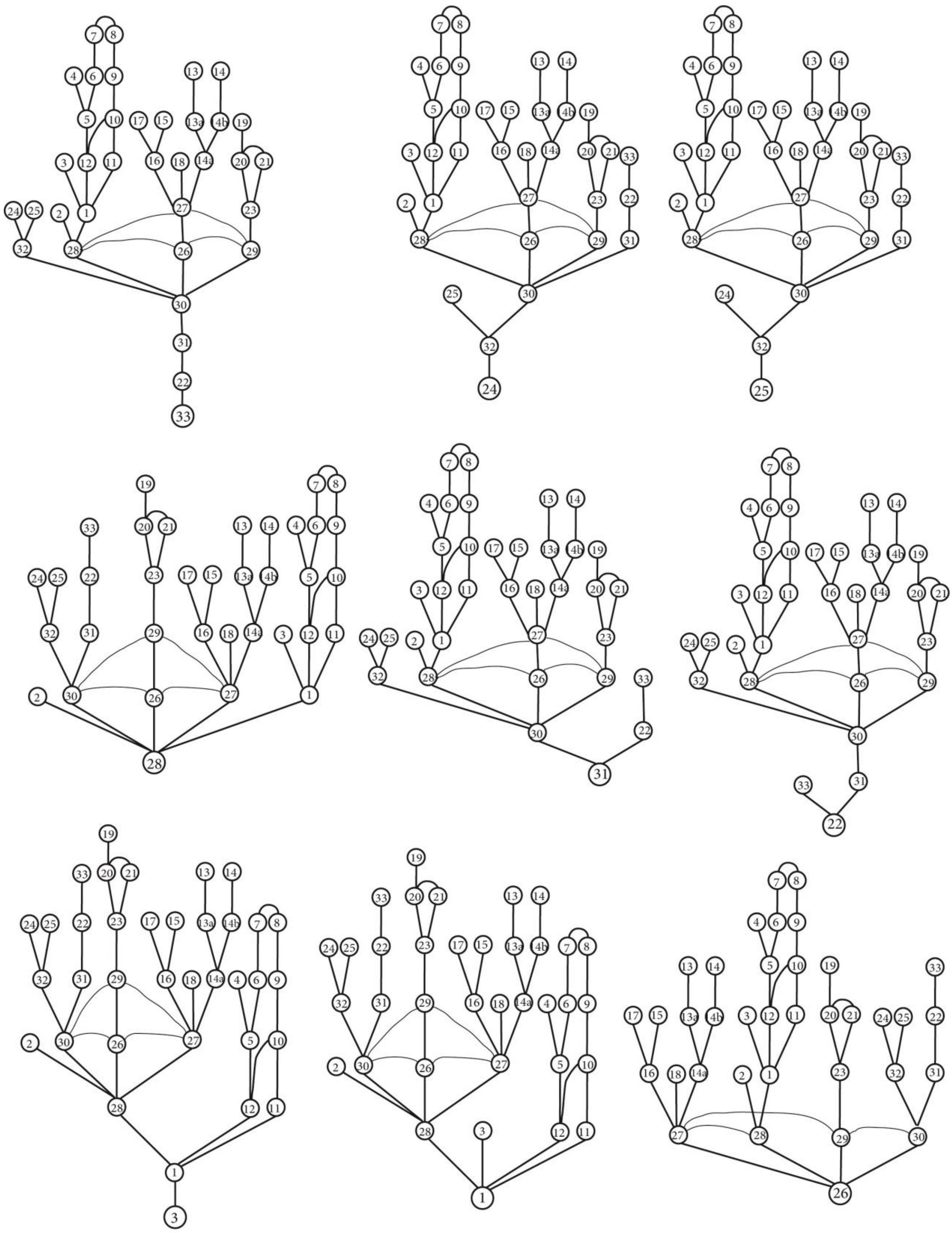

Figure 17: Gamma maps for spaces 25,24,33,22,31,28,26,1 and 3 in Jebel Khalid palace

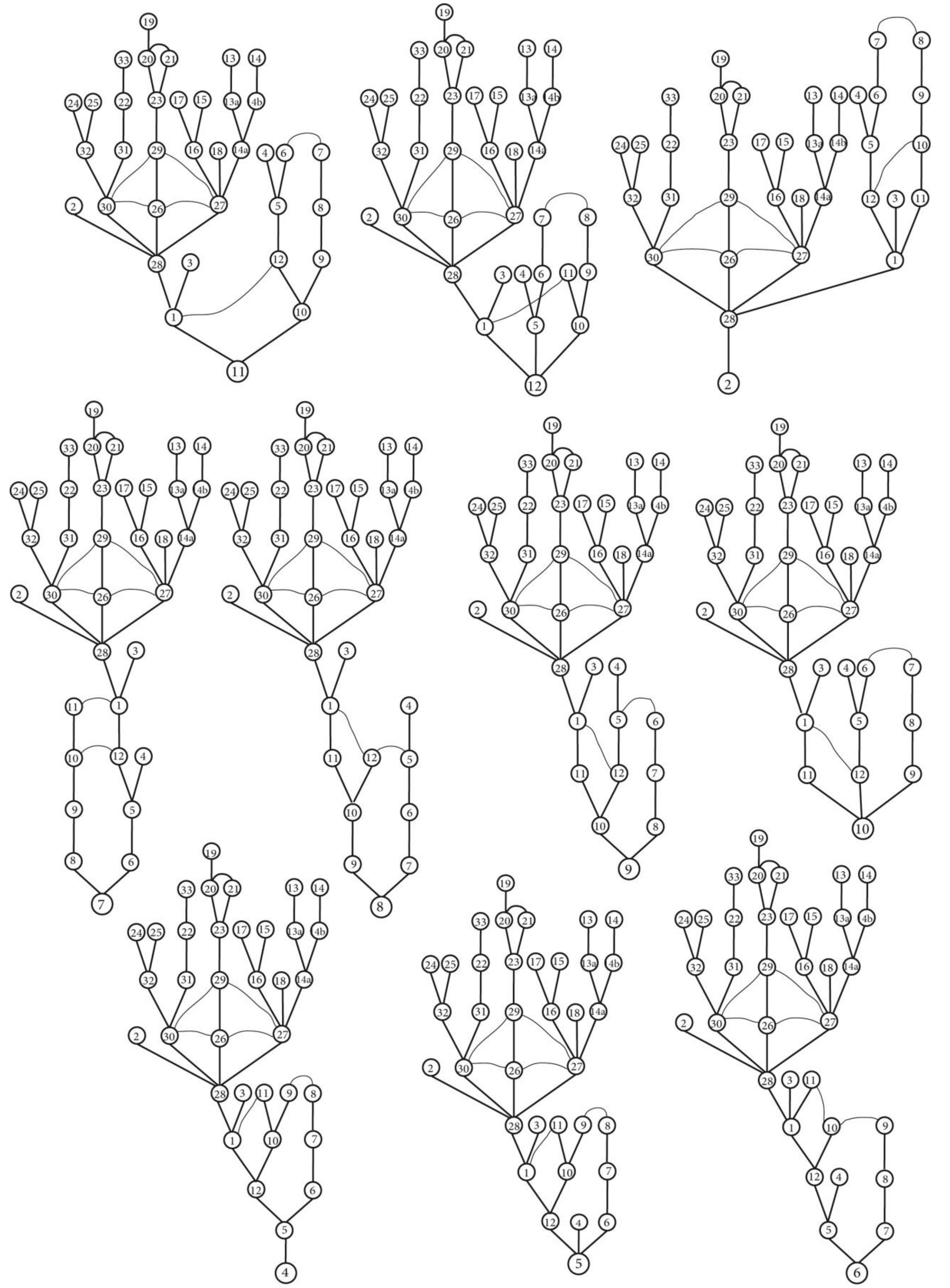

Figure 18:Gamma maps for spaces 2,12-4 in Jebel Khalid palace