LEARNING FROM MORPHOLOGICAL INDICATORS OF THE LIVING SPACE (QUA’A) IN THE HISTORICAL ISLAMIC RESIDENCE

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ABSTRACT

One of the most important parts of the residential building in Islamic architecture is the living space (Qua’a). The main Qua’a is the space used in design during Mamluk and Ottoman periods as a living space for receiving and entertaining guests. In the Islamic house during this period there were several Qua’as in each house but the main one was usually located on the ground floor. The purpose of this study is to identify the morphological indicators and proportions of the Qua’a to enhance the design process. A sample of five different living spaces in five different historical Islamic houses were studied to achieve this. The samples were selected after a comprehensive historical study on the Islamic houses that were built in Cairo during the Mamluk and Ottoman periods. The statistical description used for the analysis of the morphological indicators and parameters is form, context, opening ratio, plan aspect ratio (PAR), area aspect ratio AR (AR), ratio of perimeter to height (RPH), and volume aspect ratio (VAR) of the Qua’a in the Islamic house. The morphological indicators and parameters for the study are carefully selected based on their impact on the performance of such spaces and how these spaces impact on environmental and psychological aspects. The findings of this study will reflect the way these components interact and if they are correlated. The research constitutes a pilot study, any statistical outcome will require involving a larger sample.

Keywords: Islamic architecture, living space, Qua’a, morphology indicators, design parameters.

1 INTRODUCTION

Ever since humans lived in caves for shelter people looked for their needs and comfort. Human comfort whether physiological or psychological remains the main target of architecture design. Islamic architecture has always been and will still be a role model in providing comfortable beauty ratios whether by using the golden ratio, Fibonacci series, or other mathematical ratios. Nevertheless, numerous architectural features participate in the comfort quality. Some of these features are form, location, context, and window to wall ratio (WWR) of interior spaces. In addition to the previously mentioned features, this study focuses on the morphological indicators of the living space in the Islamic residential Qua’a. This research sets a pilot study to find out if there is a significant morphology of the residential Qua’a. This is quantitative research that depends on a survey process and adopts an inductive methodology. Residence in Islamic architecture from the late Mamluk period (1259 AC–1517 AC) throughout the Ottoman period (1517 AC–1805 AC) were different in scale according to household status. As a result, the traditional residences varied from palaces and houses to collective housing units. The living space Qua’a which is part of the residential building in Islamic architecture was used as a living space. It was usually accessible from the courtyard at the centre of the house. In Islamic architecture, a residential building could contain several Qua’as. The main Qua’a was used for receiving male guests (Salamlek) and is usually located on the ground floor. Other chambers could be for the ladies and other members of the family (Haramlek) on the upper floors. To hide the female from being seen by male guests and at the time allow them to watch the events occurring in the Qua’a. Privacy was very important in Islamic architecture. Lattice windows (Mashrabeyia) were installed in almost all the windows. Some Qua’as were designed for winter living space and others for

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summer living space. In general, all Qua'as consisted of a Durqa'a and one, two, or four "Iwans" (a three-walled area with a ceiling) flanking from a central lower Durqa'a. The Durqa'a was usually, covered by a skylight (Shokhshekha), higher in height and lower by one step containing a fountain. A view of the lattice window and the skylight (Shokhshekha) of the main Qua'a at Bayt al-Suhaymi, Old Cairo can be shown in Fig. 1(a) and (b). The Qua'a itself was usually double or triple floor height, with a lot of distinctive Islamic ornamentation features (marble arabesque, calligraphy, wooden cupboards). Marble flooring and walls, mostly wooden roofing with coloured glass clerestory windows were part of the beautiful Qua'a design. The name "Qua'a" in religious buildings developed from the residential Qua'a where religious lessons took place in early Islam by householders [1]. Historically, later mosques developed the central opened courtyard (Sahn) which became a Durqa'a in time. Further on, the Durqa'a became closed and developed into a Durqa'a with one, two, or four Iwans.

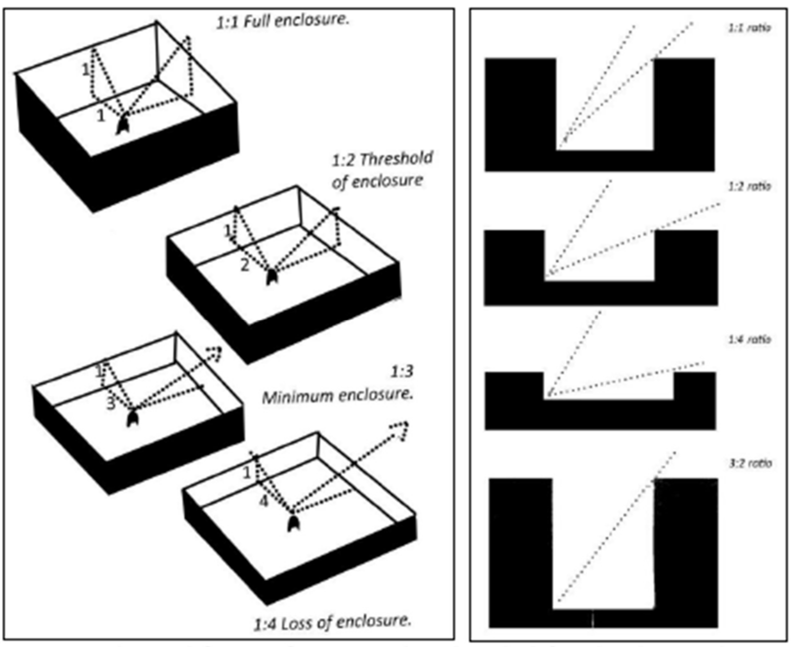
(a) (b)

Figure 1: (a) Lattice window; and (b) Skylight (Shokhshekha) of the main Qua'a at Bayt al-Suhaymi, Old Cairo, Egypt.

2 LITERATURE REVIEW

Many parameters contribute to building design for human comfort. In a study made by Pathirana et al. on the effect of building shape, orientation, window to wall ratios, and zones on the energy efficiency of naturally ventilated houses in a tropical climate it was found that a rectangular shape with a staircase positioned in the middle of the house provided higher thermal comfort for WWR of 20 and the L-shaped models when the staircase was positioned at the short corner or middle [2]. This WWR changed the thermal comfort by 20%–55% [2]. Moreover, the results show an effect when the zone sizes and location change [2].

Later on Wahba et al., studied the green envelope in a hot arid climate and showed that the temperature reduces by an average of 100°C throughout the day when implanting the walls [3]; and Daemei et al. studied the vernacular architecture patterns to improve natural ventilation and showed that if the rectangular form is turned into an L-shape, it can offer a better flow pattern for wind in all rooms [4]. Current thermal comfort studies incorporate many factors in the built environment, such as form, size, orientation, and building materials to improve the energy consumption. Vázquez-Torres and Gómez-Amador measured many other variables that affect thermal comfort and indoor air quality indices [5]. In the Vázquez-Torres and Gómez-Amador study 18 variables were added such as total surface area, room dimensions, and ceiling height [5]. To find a correlation between the volume of architecture space and workers' thermal comfort De Oliveira found from his analytical study in real work environments that there was no significant correlation between the volume of architectural spaces and workers' thermal comfort since the data support the null hypothesis [6]. In another study by Muhaisen on the effect of aspect ratio (H/W) on the thermal performance of buildings in the Mediterranean climate, it was found that "the received solar radiation is reduced by 130.2% in summer with increasing the aspect ratio from 0.5 to 4.0 at (N–S) orientation" [7]. The aspect ratio of 4.0 in narrow canyons provides the best energy efficiency throughout the year [7]. In a study made by Yousef on a sample of 18 Durqa'as of Mamluk schools (Madrassa), it was found that most of the Durqa'a in Islamic architecture were square-shaped [8]. In Yousef's study it was found that W:H ratio of the Durqa'a is equal to 1:1.5, which provides a feeling of claustrophobia when opened to the sky as can be shown in Fig. 2(a) and (b). Table 1 shows the enclosure ratios used for the experiment and existing literature. Also, most of the values of the degree of exposure to the sky AR (area aspect ratio) of the Durqu'a in the Mamluk schools were less than 1.0 which is considered a very low value, that is why the Durqua'a was later covered first by thick textile (Sahab) then fully covered having a skylight (Shokhshekha) [8]. As for the mean PAR (plan aspect ratio) value (W:L) of the Durqa'a it is 0.94 which is within the range (1–0.7) to achieve the best ventilation [9]. Most of the previous studies discussed ventilation and thermal comfort from different perspectives and approaches. Many others have studied luminous comfort. And with the progress of the simulation programs, magnificent results have been achieved. Hence, the importance of this research lies in trying to study the morphological indicators and proportions of the Qua'a for the best psychological comfort quality. And since many studies were done on courtyards or other architectural spaces using different architectural features that contributed to passive cooling and lighting strategies, this research focuses on the residential Qua'a (closed living space).



(a) (b)

Figure 2: Enclosure definition. (a) Spreiregen (1965); and (b) Hedman and Jaszewski (1984) [10].

Table 1: Enclosure ratios used for the experiment and existing literature [10].

Spreiregen (1965)		**Experiment**		**Hedman and Jaszewski (1984)**	
Definition	Building façade height to frontal field of view width	Building height to the width between buildings	Definition	Street wall height to width	Definition
		3:2	Claustrophobic	3:2	Claustrophobic
Full enclosure	1:1	1:1	Full enclosure	1:1	Strong spatial definition
Threshold enclosure	1:2	1:2	Sufficient spatial containment	1:2	Sufficient spatial containment
Minimum enclosure	1:3	1:3	Weak sense of space	–	
Loss of enclosure	1:4	1:4	Weak sense of space	1:4	Weak sense of space
		1:6	Weak sense of space		
		Less than 1:8	Weak sense of space		

3 CASE STUDY: MATERIALS

Islamic Cairo locates a lot of historic Islamic buildings. Several of these buildings are listed in the Islamic and Coptic Antiquities Registration Centre [8]. For this study, five residential buildings were selected as study samples from both Mamluk and Ottoman periods focusing on the living space (Qua'a). Accordingly, the Qua'a of the residential buildings belonging to the Mamluk and Ottoman-era for this study are monitored in a historical sequence according to the construction year. A brief description of the study samples can be shown in Table 2. In this study, three samples belong to the Mamluk period, and two samples belong to the Ottoman period, the projections for each of them are covered, plans, and sections, to reveal the morphological design and the proportions of the Qua'a.

3.1 Site description

The five existing buildings located in hot arid regions of northern Egypt are selected for the study. Fig. 3 shows the Koppen–Geiger climate classification map.

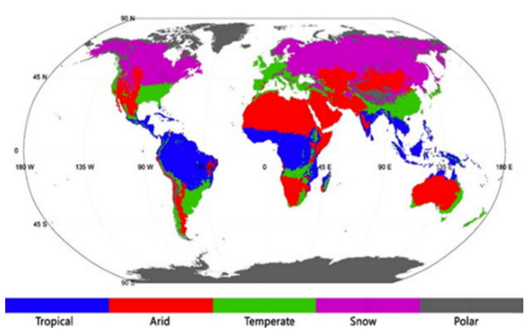


Figure 3: Koppen–Geiger climate classification map [11].

Table 2: Brief description of the residential buildings used for the study.

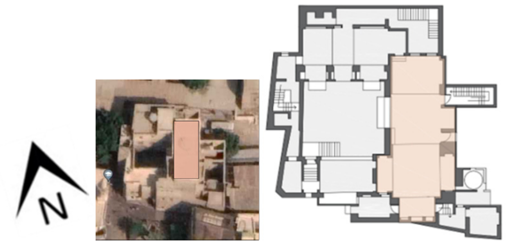
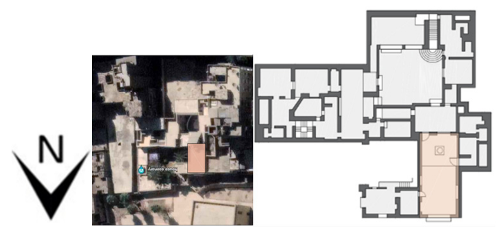
Study sample	Parameters	Description	Ariel view and plan
First: Qasr Al-Amir Bashtak	Location	Qasr al-Amir Bashtak, El-Gamaleya, Cairo Governorate	
	Geographic zone	30.05°N, 31.26°E	
	Code	QAB	
	Building type	Residential	
	Area footprint	4,620 m^2	
	Project scope/level	Living space (Qua'a)/first floor	
	Completed	1339 AC	
	Tool	Observation	
	Goal	Identify morphological indicators	
Second: Manzil Zaynab Khatun	Location	Manzil Zaynab Khatun, El-Darb El-Ahmar, Cairo Governorate	
	Geographic zone	30.05°N, 31.26°E	
	Code	MZK	
	Building type	Residential	
	Area footprint	476 m^2	
	Project scope/level	Living space (Qua'a)/first floor	
	Completed	1468 AC	
	Tool	Observation	
	Goal	Identify morphological indicators	
Third: Bayt Al-Kritliya (Gayer Anderson Museum)	Location	Bayt al-Kritliya (Gayer Anderson Museum), El Sayeda Zeinab, Cairo Governorate	
	Geographic zone	30.03°N, 31.15°E	
	Code	BAK	
	building type	Residential (currently museum)	
	Area footprint	1,830 m^2	
	Project scope/level	Living space/first floor	
	Completed	1632 AC	
	Tool	Observation	
	Goal	Identify morphological indicators	

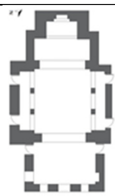
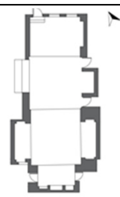
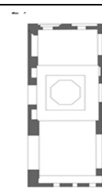
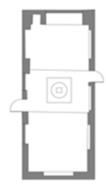
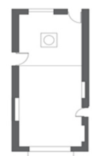
Table 2: Continued.

Study sample	Parameters	Description	Ariel view and plan
Fourth: Bayt Al-Suhaymi	Location	Bayt al-Suhaymi, Al Moez Ldin Allah, Cairo Governorate	
	Geographic zone	30.05°N, 31.26°E	
	Code	BAS	
	Building type	Residential	
	Area footprint	1,780 m^2	
	Project scope/level	Living space/ground floor	
	Completed	1648 AC	
	Tool	Observation	
	Goal	Identify morphological indicators	
Fifth: Manzil Ibrahim Katkhuda Al-Sinnari	Location	Manzil Ibrahim Katkhuda al-Sinnari, El Sayeda Zeinab, Cairo Governorate	
	Geographic zone	30.05°N, 31.26°E	
	Code	MIS	
	Building type	Residential	
	Area footprint	1,184 m^2	
	Project scope/level	Living space (Qua'a)/first floor	
	Completed	1794 AC	
	Tool	Observation	
	Goal	Identify morphological indicators	

3.2 Study sample

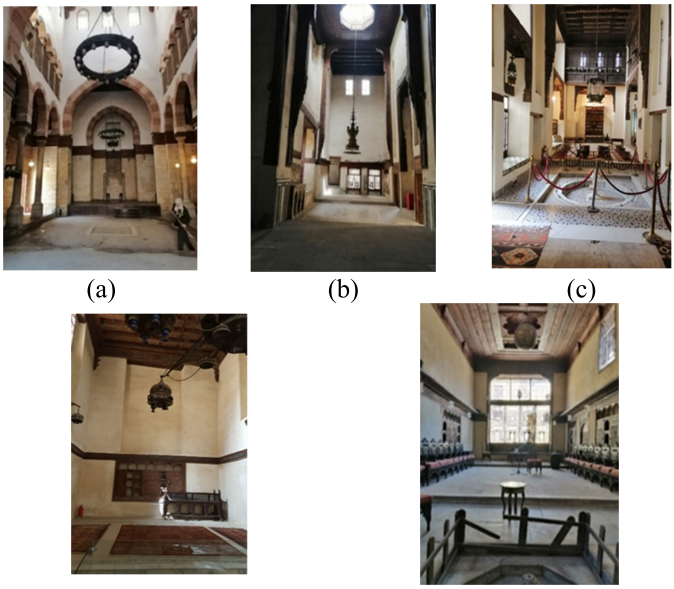
The living spaces (Qua’a) selected for the study are randomly chosen from the historic Islamic residential buildings of the same climatic zone. All buildings built within the Mamluk and Ottoman era, represent standard residential spaces in Old Cairo, Egypt. Usually living space (Qua’a) standards are almost rectangular, even when taking a four perpendicular Iwan shape the side Iwans are smaller in size. Table 3 gives a brief description of the study samples in baseline condition. Fig. 4 shows a view of the study samples Qua’a in (a) Beshtak Palace; (b) Zeinab Khatoun House; (c) Kritliya House (Gayer Anderson); (d) Bayt al-Suhaymi and (e) El Sinnari House.

Table 3: Baseline condition of the selected study samples.

Qua’a description	QAB	MZK	BAK	BAS	MIS
Form					
Context	North/west	North/west	South/west	East	North, east and west
Length (m)	21	19	24	15	12
Width (m)	8	6	7	6	5
Height (m)	9	14	8	7	6
Material and finishing	Floor	Marble	Marble	Marble	Marble
	Wall	Brick	Brick	Brick	Brick
	Ceiling	Wood	Wood	Wood	Wood
WWR	16%	18%	45%	14%	40%
Window type	Lattice /wood	Lattice/wood	Lattice/wood	Lattice/wood	Lattice/wood
Skylight	√	√	√	√	–

3.3 Morphological indicators

Several elements influence the morphology of a building. For example, some of the elements that influence the aesthetics of residential buildings are plan shape, building height, story height, voids, open spaces, circulation space, and roof [12]. In the study made by Yousef, the morphological indicators and the proportions from different aspects ratios; VAR (W/W:L/W:H/W), PAR (W:L), AR (A/H^2), and RPH (P:H) were analysed statistically to reveal the difference between the courtyard and Durqa’a in Islamic architecture [8]. In this study shape, orientation, WWR, VAR, PAR, AR, and RPH parameters are used for measuring comfort performance in some of the aesthetical measures of the Qua’a in the historical Islamic residential building. Table 4 shows the calculation indicators used in the study.



(a) (b) (c) (d) (e)

Figure 4: A view of the study samples of a Qua'a in: (a) Beshtak Palace; (b) Zeinab Khatoun House; (c) Kritliya House (Gayer Anderson); (d) Bayt al-Suhaymi; and (e) El Sinnari House showing the inner walls.

Table 4: Calculation indicators for the study. *(Source: Adapted from Yousef [8].)*

Abbreviation	**Definition**
L	The **L**ength of the space/Qua'a. The longer side
W	The **W**idth of the space/Qua'a. The shorter side
H	**H**eight of space without the crenellation. Height of Qua'a without Shokhshikha (skylight)
A	The space/Qua'a **A**rea
P	The space/Qua'a **P**erimeter
PAR	**P**lan **A**spect **R**atio Space/Qua'a, calculated according to the equation W:L
RPH	The **R**atio of the space/Qua'a **P**erimeter to **H**eight, calculated according to the equation P:H
AR	**A**rea aspect **R**atio calculated according to the equation, Space floor Area/Average Height^2
VAR	**V**olume **A**spect **R**atio, calculated according to the equation W/W:L/W:H/W

4 CASE STUDY: PROCESS AND METHOD

To achieve the objective of this research, a field survey to mark a sample of living spaces in historic residential buildings located in Egypt is described and conducted. The survey on the selected typical living spaces is recorded to find if there are significant morphological indicators and parameters.

5 CASE STUDY: RESULTS AND DISCUSSION

Most of the study samples were almost rectangular having two Iwans, mostly oriented towards the NW/SE direction, thick limestone walls, and lattice openings ranging from 14%–40%. Most of the Qua'as had a lower Durqa'a with a higher roof containing a skylight (Shokhshekha). This study monitors the three dimensions of each Qua'a and calculates the different aspect ratios of the Qua'a (Table 5), in addition to calculating the mean value, standard deviation (SD), and coefficient of variance (CV) (Table 6). Results showed that the mean value for each of the width (W), length (L), and height (H) are 6.4, 18.2, and 8.8 respectively, with SD of 1.14, 4.76, and 3.11, while the CV equals 17.81,26.15, and 35.34. By studying the mean value for the VAR; the proportions between the three dimensions of residential Qua'a W/W:L/W:H/W are 1:2.8:1.4 (Fig. 5). Moreover, the mean value for PAR is 0.36 with an SD of 0.06, and the CV equals 16.67%. The mean value for RPH is 5.44 with an SD of 1.00 and a CV of 18.38%, but the mean for AR is 1.76 with an SD equal to 0.74 and a CV of 42.05 as can be shown in Table 6. VAR comparison analysis of the Qua'a is shown in Fig. 5. Results show that the trend line between the length of Qua'a (L) and width (W) for (R^2) equals 0.66 and the correlation coefficient (R) equals 0.81. Besides, the trend line between (W) and (H) for (R^2) equals 0.03 and the (R) equals 0.17. The trend line between (L) and (H) for (R^2) equals 0.15 and the correlation coefficient equals 0.40, whereas the trend line between (P) and (H) for (R^2) equals 0.35 and the (R) equals 0.59. Finally, the trend line between (A) and (H^2) for (R^2) equals 0.03 and the (R) equals 0.18. (R) of the Qua'a W vs L; W vs H; L vs H; P vs H; and A vs H^2 can be shown in Fig. 6(a)–(e).

Table 5: Results of geometric properties and proportions of the Qua'a in the historical Islamic residential house/palace.

Building code	W	L	H	A	P	PAR	RPH	AR
QAB	8	21	9	168	58	0.38	6.4	2.1
MZK	6	19	14	114	50	0.32	3.8	0.6
BAK	7	24	8	168	42	0.29	5.3	2.6
BAS	6	15	7	90	42	0.40	6.0	1.8
MIS	5	12	6	60	34	0.42	5.7	1.7

Note: Unit = m; PAR = plan aspect ratio (W:L); RPH = ratio of perimeter to height (P:H); AR = aspect ratio (area/average height^2).

Table 6: Statistics of the Qua'a results.

	W	L	H	A	P	PAR	RPH	AR
Mean	6.4	18.2	8.8	120	45.2	0.36	5.44	1.76
SD	1.14	4.76	3.11	47.81	9.12	0.06	1.00	0.74
CV	17.81	26.15	35.34	39.84	20.18	16.67	18.38	42.05

From the statistical results of many aspects ratios of the Qua'a monitored, it can be observed that the approximated area ranged from 168 m^2 to 60 m^2 this indicates that the area reduced with time. This could be explained as cities expanded and populations increased with time, the large family house no longer existed. Residential buildings were constructed, and extended families lived in their own private residences becoming smaller in size. The mean area of the Qua'a was 120 m^2. It was also noticed that most of the Qua'as were almost rectangular in shape with mostly two Iwans, representing two-thirds of the study sample.

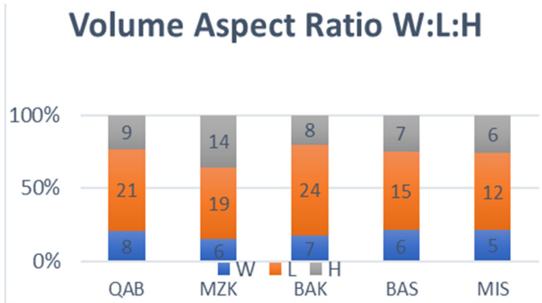


Figure 5: VAR comparison of the Qua'a.

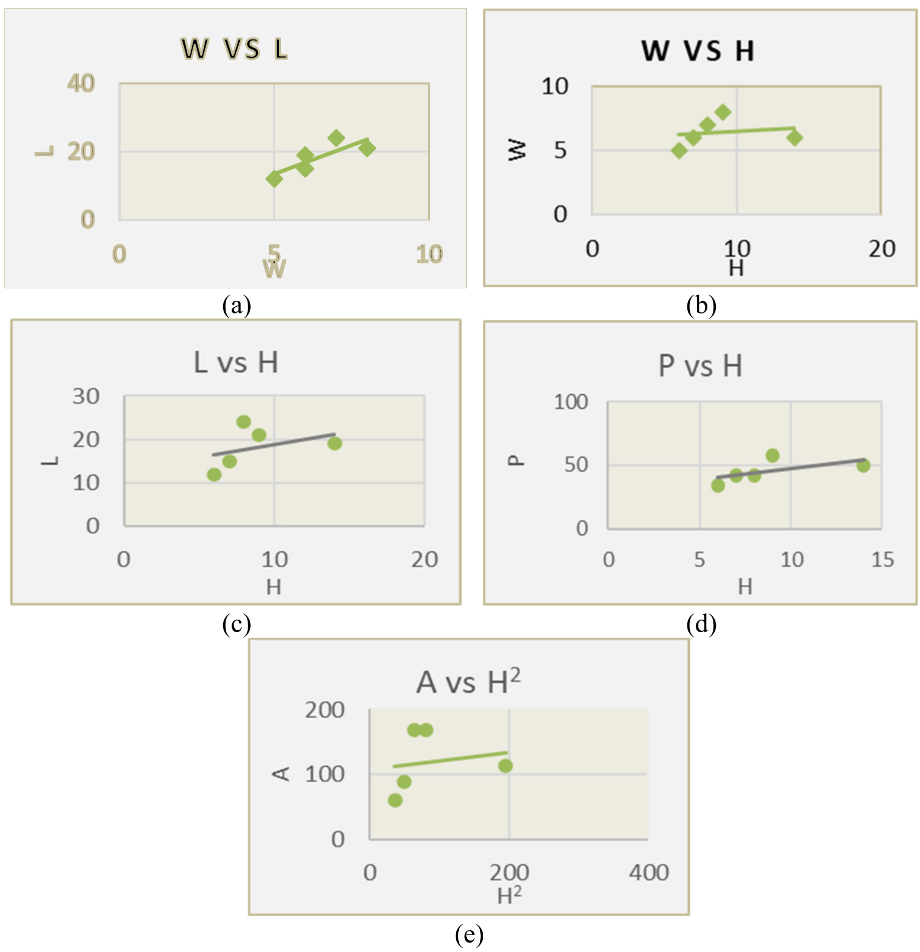


Figure 6: Correlation coefficient (R) of the Qua'a. (a) W vs L; (b) W vs H; (c) L vs H; (d) P vs H; and (e) A vs H^2.

Most of the centre area Durqa'a were lower with one step and higher in height mostly having a Shokhshekha on the top. There were groves on side walls even if there were no side Iwans, probably for seating. The mean VAR (W:L:H) for the Qua'a is 1:2.8:1.4 which indicates a weak sense of enclosure but again all Qua'as were covered despite the existence of a skylight (Shokhshekha) in most of them (8). As for the mean PAR, it was 0.36 which is considered lower than the best ventilation range (1–0.7) [9]. This value does not consider the opening's ratio consisting of lattice windows and skylights which contribute to the room's ventilation significantly in the Qua'a design. It is also noticed that the mean RPH is 5.44 which is within the suitable comfort range 4–8 [6]. As for AR which expresses the degree of exposure to the sky, the mean value was 1.76. This value is considered more than 1.0 which is considered acceptable even if not covered [3]. All residential Qua'as were covered anyway. All trendline line values were very low which indicates an almost null correlation except for W to L ratio where R^2 is 0.66 indicating moderate correlation determination and P to H ratio where R^2 is 0.35 indicating weak correlation determination despite the positive correlation coefficient in all results. The trendline in all for VAR, PAR, RHP, and AR can be seen in Fig. 6(a)–(e), respectively.

6 CONCLUSION AND RECOMMENDATIONS

Many facts can be concluded from the study of the morphological indicators of the living space in the historical Islamic residential Qua'a. This study analyses the morphological determinants of the Qua'a in the residential buildings on a sample of both Mamluk and Ottoman eras and compares them statistically based on general standards. Although this research is a pilot study results showed inconsistency in determinants and characteristics of the Qua'a. Despite positive trendline values, results are very low which indicates an almost null correlation. It is recommended that any statistical outcome will require involving a larger sample. It is also recommended, as a potential study, to study the morphological indicators of the (Qua'a) in the historical Islamic residence based on statistical analysis to verify the standards and to reach towards better residential spaces. This study can further study impacts on human comfort in real environments, to verify the standards in the literature related to the many design standards. Future studies are also recommended for more advanced analysis of other aesthetical and environmental approaches.

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