The Traditional Architecture of Mount Lebanon
Strategies and performance of the administrative palaces of Deir al-Qamar

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1. INTRODUCTION

Millennia of civilisation in the Arab region have been shaped by adaptation to hot temperatures, large diurnal variations, and a predominantly dry climate, cultivating a rich tradition of finely tuned architectural responses [1]. The climatic qualities of domestic architecture, particularly in Lebanon, have been well documented by F. Ragette [2]. However, systematic field measurements and scientific performance assessments remain limited, and non-domestic typologies are even less studied. This research documents and evaluates the environmental performance of Levantine architecture as one model of summer comfort and sits within a broader research project studying different ways of dealing with heat. Three case studies from Deir-al-Qamar were analysed: the Serail, the Caravanserail, and the palace of Beiteddine. The focus of this paper are the government seats, meaning the indoor spaces of the Serail and of Beiteddine (which held more functions, including the residence of the Emir) [3] (Figure 1). While all buildings feature traditional configurations and techniques, close analysis reveals finer strategies that further enhance summer conditions.

Figure 1: Deir-el Qamar and Beiteddine by Bartlett c. 1840

This paper is organised as follows. Section 2 presents the methodology. Section 3 describes the climate of the study area. Section 4 presents the architectural configuration of the two buildings. Section 5 presents the fieldwork results. Section 6 develops an analytical study of the summer tribunal, and Section 7 discusses the broader implications of the findings.

2. METHODOLOGY

The analysis is articulated in three phases: first architectural and experimental; second, an instrumented fieldwork campaign in July 2025, and third analytical work.

2.1 Architectural analysis

Preliminary documentary research was carried out combining historical archives, existing architectural surveys, interviews with local authorities, and a literature review to identify the relevant buildings and key spaces, and to understand their use. Buildings were visited several times during summer, enabling a deep understanding of their spatial and climatic ambiences, and allowing a geometric survey, experience of spatial and thermal transitions, mapping of openings and materialities, and identification of alterations to the original conditions.

2.2 Fieldwork

The three studied buildings were instrumented to record air temperature and relative humidity for three to four days (28/07 to 01/08) using Testo 174H thermo-hygrometers at a 15-minute interval.

The Serail, currently used as a Municipality, allowed fieldwork until the evening, which was useful for systematic spot measurements. Surface temperature measurements were taken indoors and outdoors with a Testo 810 infrared pyrometer, at 5 different hours of the day on the 29/07 and 30/07, at multiple heights and with different solar exposures, in order to characterize radiative differentials. Wind speeds were taken at the same hours with a Testo 410-1 vane anemometer at several characteristic positions. In Beiteddine, indoor surface temperature spot measurements were taken at 14:00 on 01/08.

The conditions during the campaign fall within the typical statistical conditions, which allows the data collected to be considered representative of a typical summer.

2.3 Analytic work

Data for the annual climate description was extracted from Meteonorm 8.0 [4], using Merdjaayoun as the closest representative weather station available. EN16798 [5] is used as a reference for indoor thermal comfort. For the specific case of the Serail, a 3D model was built in Rhino and analysed with Ladybug Tools [6] to extract shading masks with equidistant projections, to calculate the contribution of radiative surfaces, and to calculate Mean Radiant Temperature. PET was estimated via RayMan [7,8] to compare the thermal sensation between the courtyard and indoors.

3. THE CLIMATE

Lebanon lies in a climatic transition zone between the eastern Mediterranean basin and the Arabian Peninsula, which results in a Mediterranean climate characterised by two distinct seasons: a hot, dry summer and a mild, wet winter. The mountain range of Mount Lebanon rises parallel to the coast and reaches elevations of over 3,000 m, acting as a climatic filter between the maritime frontage and the inland regions. Altitude produces a typical vertical thermal gradient and a deflection and acceleration of the prevailing winds, creating localised wind channels at the valley scale (Figure 2)

Deir-el-Qamar (33.7°N) is located on the western slopes at 800 m a.s.l. and sits within the climatic zone of the Western mountain. This climate falls between Csa and Csb of the Köppen–Geiger classification (Figures 3 and 4). Summers are characterised by great atmospheric stability, clear skies, and intense solar radiation reaching almost 1000 W/m² daily. The average high temperature is approximately 29°C, while the average low is around 17°C, suggesting thermal inertia as an effective means of cooling. The highest solar altitude reaches approximately 80°, maximising irradiance on horizontal surfaces and minimising it on vertical façades. Compared to Beirut, where the average nocturnal low reaches 24°C in summer, the mountain climate is significantly milder at night, a difference that makes passive cooling strategies considerably more effective here. Winter temperatures average around 8°C; the combination of strong direct solar radiation and a dry atmosphere keeps daytime temperatures above 10°C, while nights rarely drop below 0°C, meaning that even modest direct radiation can bring conditions to comfortable levels. A comparison of the climates of Beirut and Merdjaayoun is also provided in Figure 3.

Beiteddine is located only 7 km from Deir-al-Qamar but sits at 860 m altitude, representing approximately 0.4°C less in air temperature at all times [9, 10].

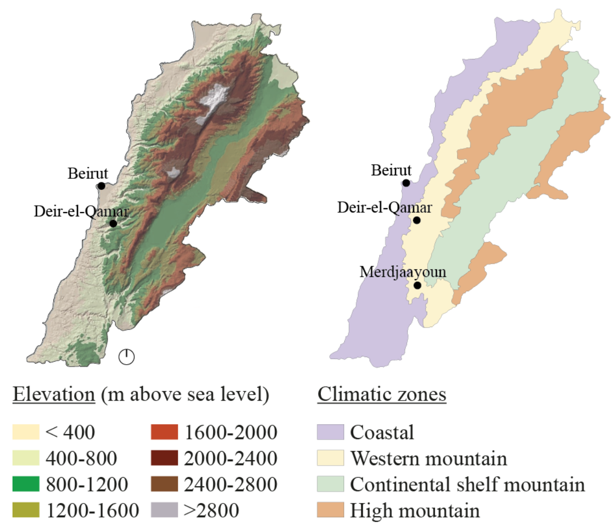

Figure 2: Topography of Lebanon and climate zones

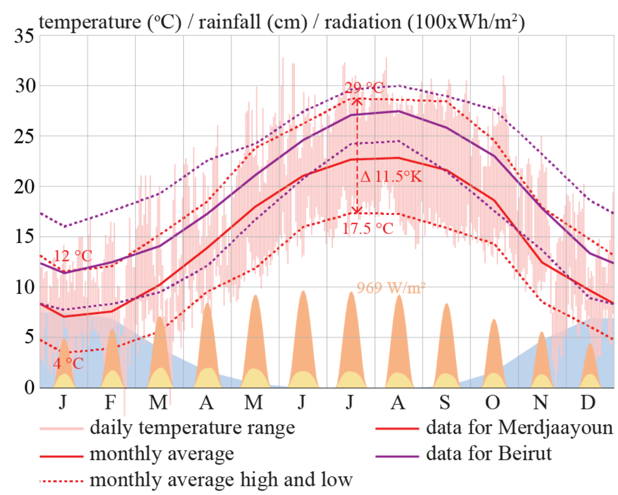

Figure 3: Climate summary for Merdjaayoun and Beirut

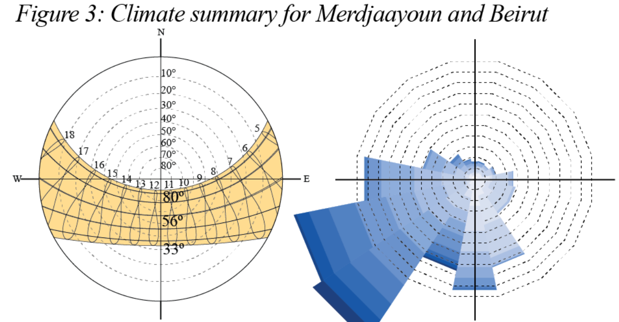

Figure 4: Sun path for lat. 33°and summer wind rose for Beirut

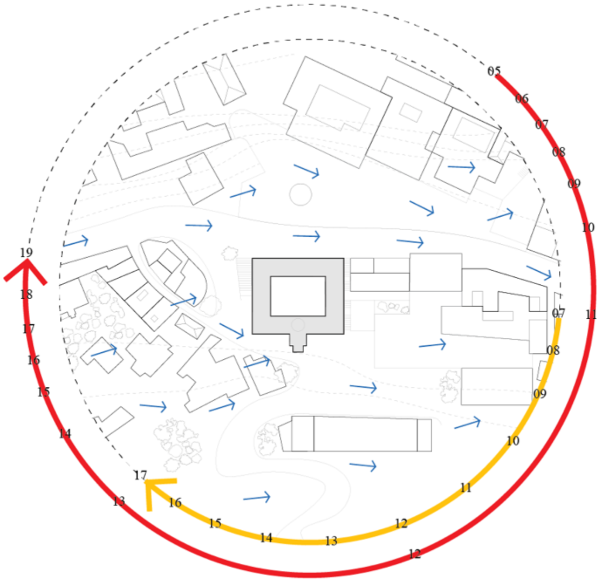

Figure 5: The Serail and sun path in summer and in winter

Figure 6: Deir-el Qamar. Photograph by Philippe Guersan

Figure 7: Aerial view of Deir-el Qamar, image from Apple maps

4. ARCHITECTURAL CONFIGURATION

4.1 Deir-al-Qamar

Formerly the capital of the Emirate of Mount Lebanon during the 16th–18th centuries, the historic village retains a dense, mineral urban fabric organised along a primary circulation axis that structures a succession of administrative, religious, and residential buildings. The village is situated on a south-facing hillside, which directly shapes the relationship between façade orientation and solar exposure on the one hand, and between valley morphology and wind circulation on the other. Within the valley, the dominant synoptic airflows are channelled into a locally redirected breeze regime along its axis, which was confirmed by field observations and air velocity measurements at the Serail. The main buildings are oriented south to south-west to capture both the winter sun and the locally prevailing westerly winds.

4.2 The Serail

The Serail of Emir Youssef Chéhab (Figure 5), built in the late sixteenth century, is located at the heart of the village (Figures 6 and 7). It served as a government seat for administrative and military organisation, with formal reception spaces for receiving petitioners, ceremonial gatherings, and court proceedings. Following the transfer of the seat to Beiteddine in 1818, the Serail successively served as a residence, soap factory, dyehouse, stable, and prison, before its current use as a Municipality.

As an institutional building, it is representative of how administrative architecture mobilises, concentrates, and refines the climatic principles embedded in the regional vernacular tradition (Figures 8 and 9): a compact and massive structure organised around a central courtyard; flush exterior walls with small openings that limit heat gains while admitting sufficient daylight; thick stone walls and floors providing substantial thermal inertia; paired low- and high-level openings; and a programmatic organisation based on the seasonal differentiation of use. Interior nomadism -defined here as the movement of occupants within a building in response to differentiated climatic conditions- is a characteristic of this architectural tradition, expressed here through the distinction between the summer and winter tribunals (Figures 10 and 11).

The primary access is through a street-level entrance, small in scale for security purposes. From this entrance, the courtyard is reached off-axis via its north-east corner. As it is highly mineral and open to the sky, the immediate sensation upon entering is one of strong heat. This thermal stress is only partially alleviated when wind enters the courtyard via the *liwan*, a traditional feature of this architecture: an open but shaded space, oriented toward the prevailing winds so as to channel airflow into the courtyard, while also providing a pleasant exterior space to rest. Inside each space, their specific conditions reveal finely tuned, seasonally adapted strategies.

4.2.1 The Summer tribunal

The summer tribunal (Figure 12) covers an area of approximately 108 m², with ceiling heights ranging from 5.5 m to 10 m and a total volume of approximately 670 m³. It comprises four interconnected rooms, of which eight out of ten façade segments are exposed to the exterior. This spread configuration limits the accumulation of heat and humidity generated by occupants, and favours heat dissipation when internal gains accumulate - for example during a celebration.

At latitude 33.7ºN, in summer, the sun is stronger on the east and west facades, whereas at midday, when its azimuth is to the south, the sun is almost vertical (80º), and is less strong. The main façades are oriented north–south, therefore the orientations subject to the least solar radiation in summer, and windows are relatively small at approximately 0.80 × 1.70 m, limiting further solar gains.

Three rooms form a reception zone facing north towards the courtyard and are topped by dome openings, suggesting a mechanism for warm air evacuation through thermal stratification.

The judgment zone occupies a projecting volume extending beyond the general façade alignment, oriented perpendicular to the prevailing winds. Openings on two opposing sides allow a continuous breeze through the space where the Emir spent much of his time- a finding corroborated by both field records and air velocity measurements. At the back, a lighter wooden apse can be fully opened to the landscape and the prevailing winds. The projected volume also helps to modulate solar exposure on the south façade by reducing the duration of direct insolation on each wall segment and thereby limiting heat build-up within the masonry. As the south façade faces the valley, the ground in front lies some 10–12 m below, which avoids the additional heat load from reflected radiation -a significant source of heat in these climates.

The walls are 100 cm thick, creating deep embrasures, and are made of limestone (consistent with the local geological substrate). On the south orientation, this thickness is sufficient to prevent direct high-angle sun (maximum altitude 80°) from penetrating into the space. The stone walls are left uncovered, maximising contact between the air and the thermal mass and reinforcing the perceived thermal coolness for occupants.

When entering from the hot courtyard, thermal relief was perceived instantly, followed by an overall sensation of coolness. Moving to the judgment zone, a breeze was always felt, most strongly at the window seat, which proved to be the most thermally pleasant space visited.

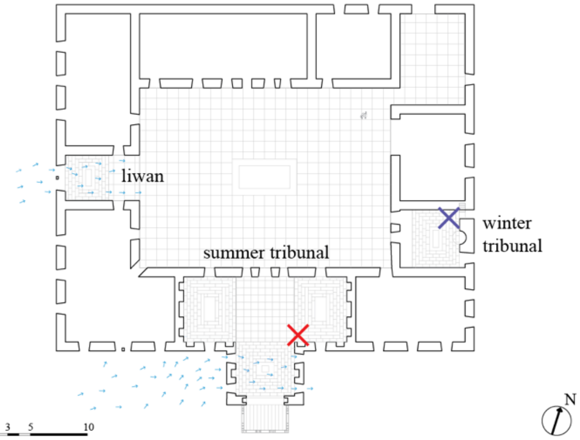

Figure 8: Plan with tribunals, direction of prevailing wind, and datalogger location

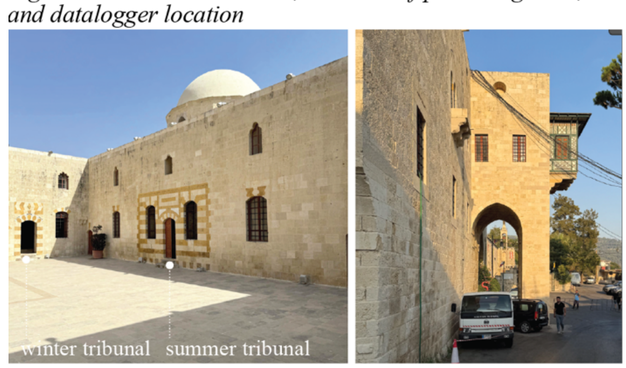

Figure 9: Courtyard view and volume of judgment area

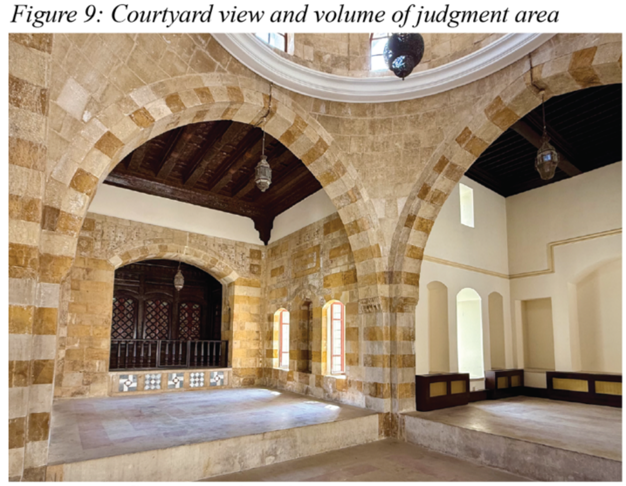

Figure 10: Summer tribunal

Figure 11: Winter tribunal

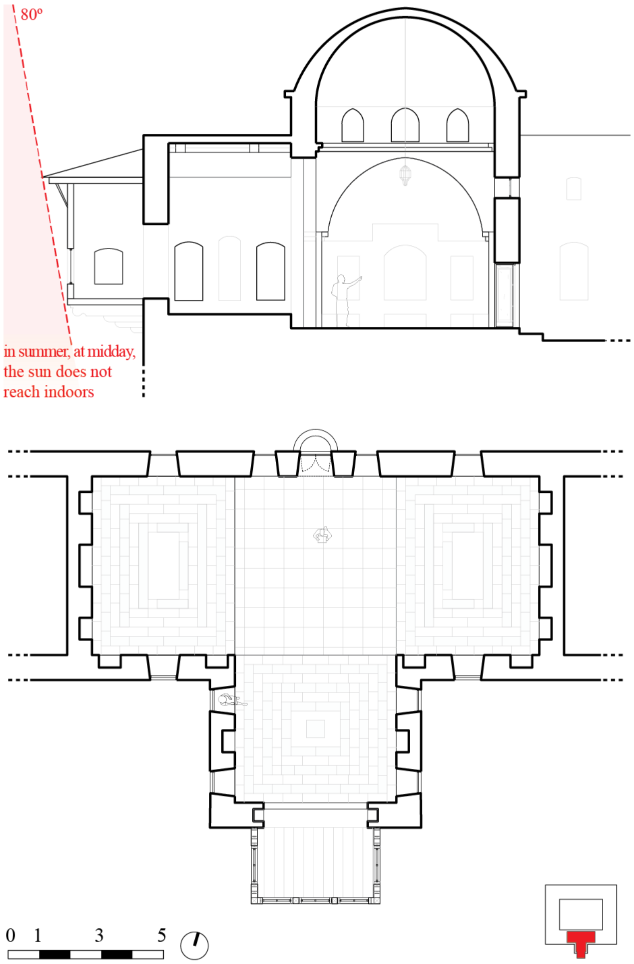

Figure 12: Serail, section and plan of the Summer tribunal

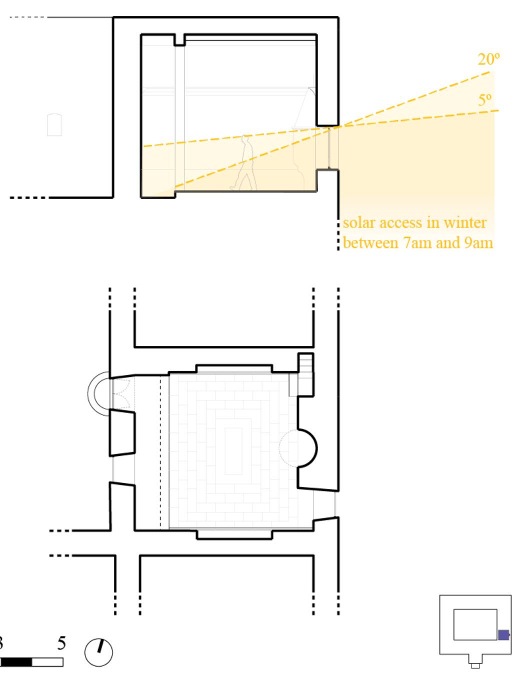

Figure 13: Serail, section and plan of the Winter tribunal

4.2.2 The winter tribunal

The winter tribunal (Figure 13) presents a near-opposite configuration: a single room of approximately 28 m², lower in height at approximately 5.3 m, with a condensed volume of 150 m³, roughly one-fifth of the summer tribunal. Only two out of four façade segments are exposed, and windows are slightly smaller at 0.80 × 1.5 m. Its central element is a fireplace, making its cold-season function explicit.

This configuration retains internal heat gains from both occupants and fire while limiting dissipation. The tribunal is located on the east aisle, away from the prevailing winds, with its main façades facing roughly east and west. The east-south-east-facing façade allows direct morning solar exposure: at this orientation, the lower sun angle penetrates the 0.90 m-thick walls, contributing to the early warming of the masonry at the start of the day and enhancing the occupants' perception of warmth, well suited to the formal meetings that took place here during the morning.

The limestone walls are lined with timber panelling and polished marquetry, which partially decouples the interior air from the thermal inertia of the stone. This lining mitigates the cooling effect of the mass (both by preventing direct contact with the cool surface and by attenuating radiative heat loss toward cold wall surfaces) and reflects firelight. The lining can be read as a thermal decoupling device adapted to winter use, where the priority is immediate occupant warmth rather than long-cycle inertia.

When entering this tribunal in summer, the thermal sensation is not markedly different from that felt outdoors in the shade, an indicator of heat rather than cool, confirming that the two spaces constitute a deliberately opposed climatic pair.

4.3 The Palace of Beiteddine

Following a period of political consolidation and economic prosperity, Emir Bashir II relocated the seat of government to a new palace as the material expression of his political authority. The site sits on a hill at the far end of the valley, approximately 7 km from Deir-el-Qamar and slightly higher in altitude at 860 m. From this position, the palace dominates the valley and commands a direct view of the village (Figures 14 and 15).

Built between 1788 and 1818 (supposedly commissioned to an Italian architect), the palace provided the spatial framework required for an increasingly sophisticated court life and a more centralised exercise of power. The complex is organised around three courtyards at different levels, each serving a distinct function. The first courtyard, Dar-al-Baraniyyeh, is situated at the lowest level, it is the largest and most public, where visitors would arrive and could stay for up to three days; two symmetrical external staircases provide access to an upper gallery leading to the second courtyard. Dar-al-Wousta organises the administrative functions around a large fountain; to the south, the ministers' reception rooms act as a hinge between the public and administrative areas, all connected via a small, protected gallery. To the north is the Salamlek, the Emir's reception area, with its waiting rooms, its large hall, and access to the upper Harem. The connection is made via two symmetrical staircases leading to a south-facing upper gallery where the Emir spent the early morning. The third courtyard, Dar-el-Harim, is located on the highest level and hosts the Emir's private apartments (which remain inaccessible in summer as they still serve as the President's summer residence).

The palace follows the traditional characteristics of the region: massive construction, relatively small openings, galleries as intermediate spaces, and heavy thermal inertia; but with an organisational logic that reflects mainly the hierarchies of its occupants and the ambition to dominate the landscape. The movement between the spaces follows a daily logic [3, 11].

The day would begin with formal governmental and judicial audiences in the reception rooms during the morning (Figure 16). Midday was devoted to prayer and private rest. The customary afternoon occupation was outdoor activity, which often took place in the palace gardens; though once or twice a week, distinguished guests would be received in the Salamlek. The late afternoon was spent in the hammam, where political conversation continued informally, before the Emir retired to his private apartments. This daily circuit, from the most public to the most private, from the coolest morning hours to the heat of the afternoon, constitutes a form of climatically structured daily movement through the building.

The main governmental spaces were therefore the reception rooms (described in the following section), but the hammams and the gardens are an integral part of the Emir´s governmental sequence (Figures 17, 18, 19, 20).

The hammams are located off the courtyard circuit, between the administrative and private areas. Completely enclosed (thick walls, vaulted stone roofs, no windows), their envelope produces the hygrothermal stability their function requires. Daylight enters only through small circular oculi arranged in geometric patterns across the vaults, creating a diffuse, homogeneous light punctuated by moving shafts of sun on the floor.

The gardens were private, and located in a lower level, away from the public view, in contact with the storage caves and with a private access.

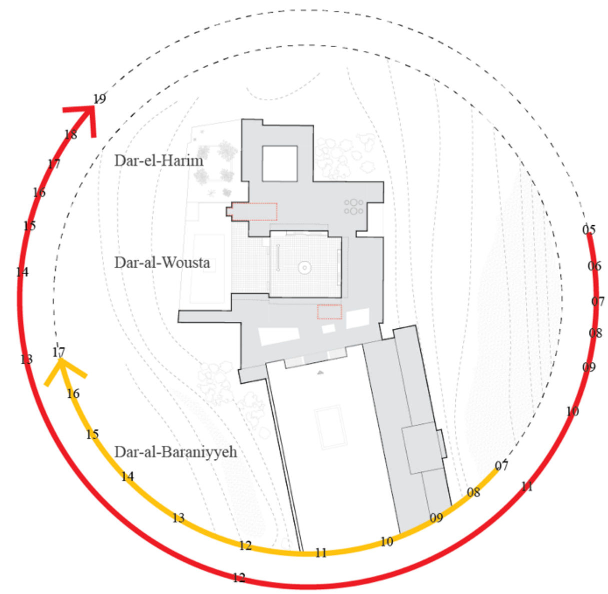

Figure 14: Beiteddine and sun path in summer and in winter

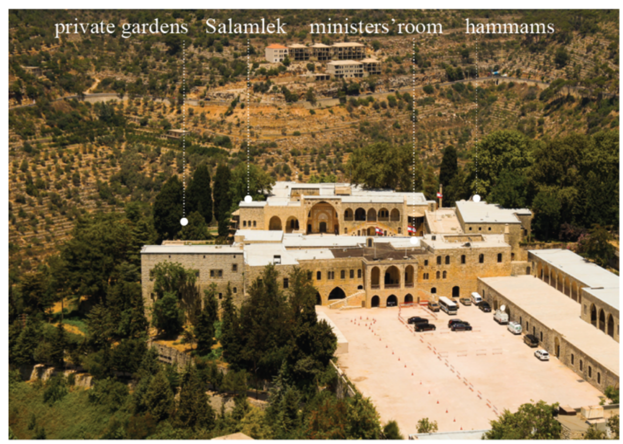

Figure 15: Beiteddine, image from monnuage.fr

Figure 16: the Emir Bashir in the hall of the Salamlek, 1823 (7am)

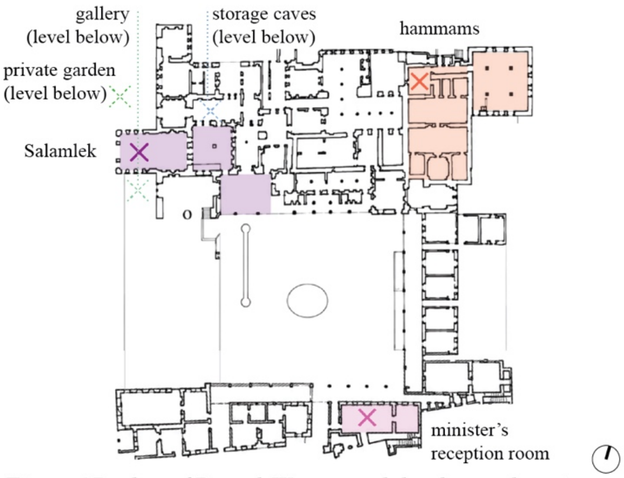

Figure 17: plan of Dar-al-Wousta and datalogger location

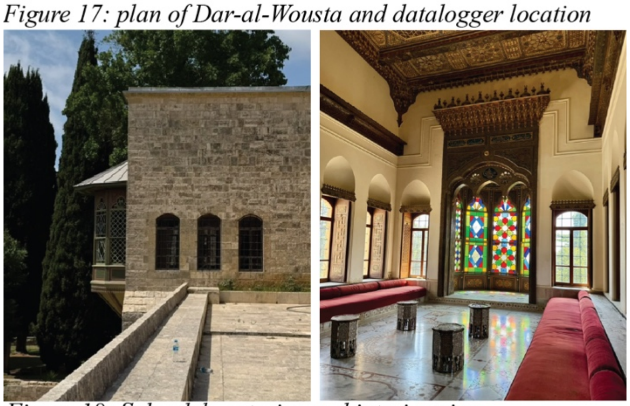

Figure 18: Salamlek, exterior and interior view

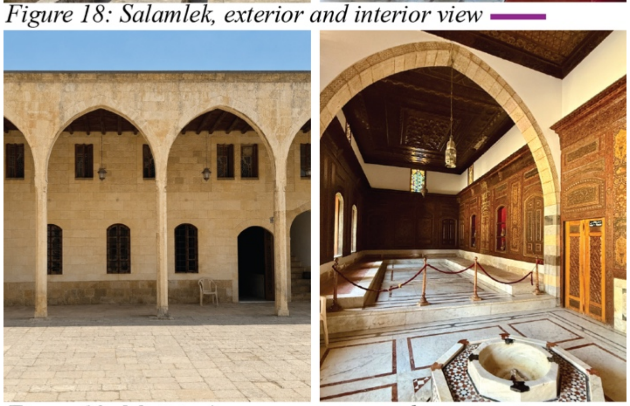

Figure 19: Minister's room, exterior and interior view

Figure 20: Hammam and interior storage area

4.3.1 The reception rooms

The three main reception rooms share the same apparent typology: an antechamber with a small fountain (which likely served to mask conversations in the adjacent room while contributing to a sense of freshness) followed by the main reception hall with perimeter floor seating. Despite this shared interior configuration, the thermal sensation inside each room differs considerably, and closer observation reveals differentiated conditions, such as orientations, exposure, opening ratios, volume and amount of inertia which will be further developed in the following section.

4.3.1.1 The ministers' reception room

The small ministers' reception room (Figure 21) is set back within the building mass, facing north, and sheltered by a 3m deep gallery that protects it from direct solar radiation and rain. This results in 2 out of 6 envelope elements exposed and contact with the ground via the floor. The room measures 5×10m and stands 5.5m high (approximately 275 m³, almost the double than the winter tribunal). Windows measure 0.80×1.70m, which matches the window dimensions of the Serail, and here they are also paired with upper latticed openings that likely permitted night ventilation while maintaining security. Walls are 80–90 cm thick, but throughout, they are lined with marquetry, an unusual choice for a room that might otherwise benefit directly from its exposed thermal mass. When entering the smaller room, the thermal perception was relatively cool and pleasant.

4.3.1.2 The Salamlek

The Salamlek (Figure 22) occupies an independent projecting volume in the outermost position, facing west, with both its floor and roof exposed, resulting in 5 out of 6 envelope elements exposed. It is the largest room at 7×12.5m and 7.5m high (approximately 660m³, similar to the summer tribunal). The south, north, and west façades carry large windows of 1×2.4m (roughly double the opening area of all others studied rooms) and at the back, a very large wooden apse can open entirely toward the landscape, commanding views over the valley.

The projecting volume is oriented parallel to the prevailing winds, which considerably limits cross-ventilation. The south and west façades are fully exposed to solar radiation from midday until the end of the day. Besides, the stone floor immediately in front of the south façade reflects the radiation from the high-angled sun back into the walls and windows, adding up to the heat, and the large west-facing windows admit direct sun during the afternoon (the moment of the prominent visits). At 70 cm, the walls are the thinnest of all measured, limiting thermal inertia. While the antechamber, floor, and entrance are finished in mosaic, marble, and stone, the walls of the main room appear today to be finished in stucco, though this may not be the original finish.

Upon entering the room, the impression was immediately one of heat.

4.4 Comparison and analysis

At first glance, both buildings follow the traditional strategies of the region (massive stone construction, small openings, shaded galleries, courtyard organisation) which likely establish a shared baseline of thermal comfort. Upon closer inspection, the two buildings diverge in significant ways.

The Serail displays a refined and internally consistent climatic logic. Its spaces are calibrated not only to the season but to the specific activity and the position of the Emir: the summer tribunal capitalises on large volume, heavy inertia, shields from solar and outdoor heat, captures the breeze, evacuates warm air through dome openings, and provides the Emir´s seat as the most finely tuned position of all. The winter tribunal reverses most of the parameters, focalising as much heat as possible in the small room. This seasonal dualism constitutes the organising principle of the building.

In Beiteddine, the organising principle is the hierarchy of persons and the rhythm of the day. The Salamlek, which is the most important room of the palace, shares the volumetric ambition of the summer tribunal (Figure 23); but its large openings, thin walls, exposed walls, and solar exposure suggest that representational concerns seeking to position the Emir in a prominent position took precedence over climatic ones. The minister´s rooms seem to be more tailored to summer conditions. However, the marquetry lining limits the contact with the inertia.

Whereas in the Serail, design decisions are driven by seasonal comfort, in Beiteddine, hierarchy dominates. The result is a building where climatic intelligence and symbolic ambition coexist, but do not always coincide.

Figure 23: protrusions of the summer tribunal and the Salamlek

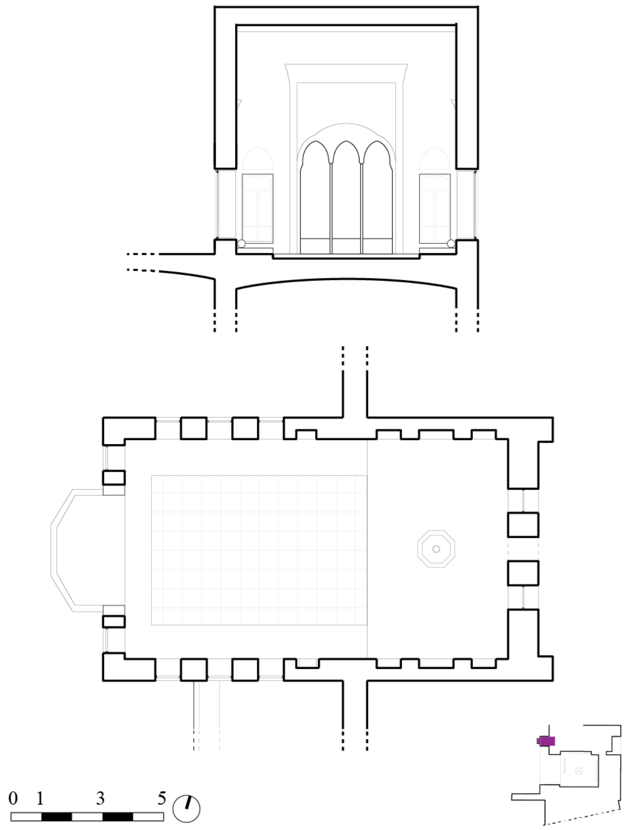

Figure 21: Beiteddine, section and plan of the Salamlek

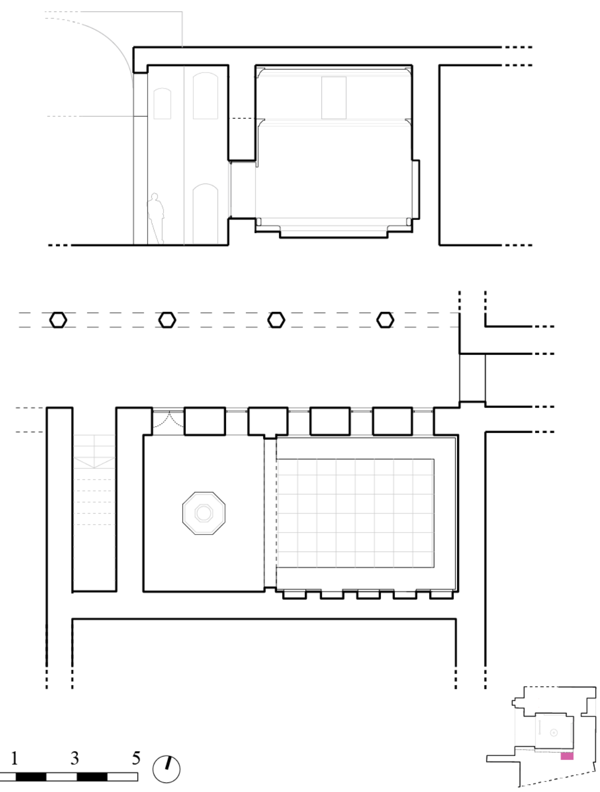

Figure 22: Beiteddine, section and plan, minister´s reception

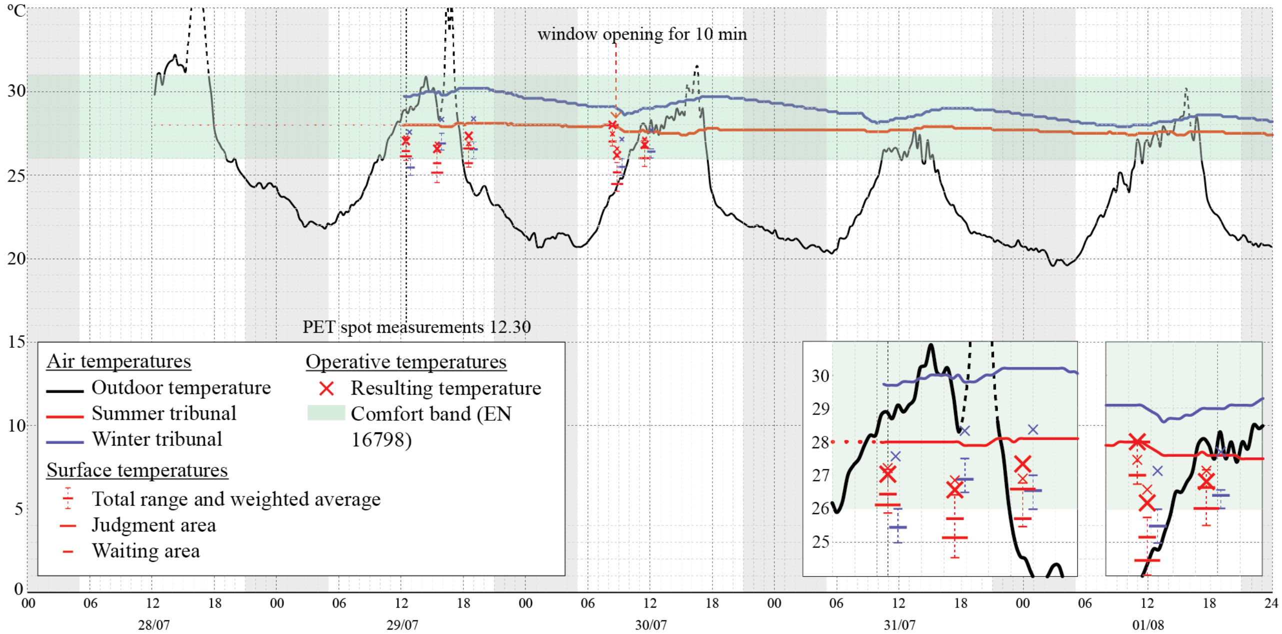

Figure 24: Air temperature recordings and surface temperature spot measurements of the winter and summer tribunals

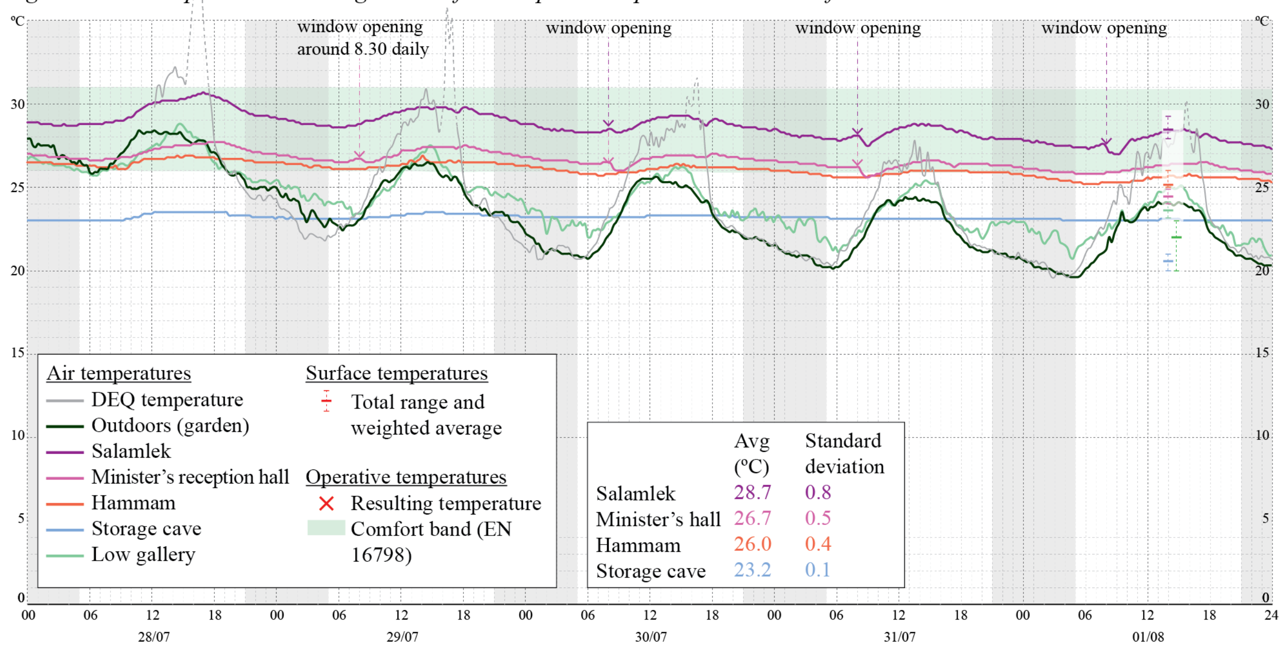

Figure 25: Air temperature recordings and surface temperature spot measurements in the Palace of Beitedine

Table 1: The Serail: Surface temperature measurements (ºC) and air speeds (m/s) outdoors and indoors

Time	Outdoors - center of the courtyard											Indoors - Judgment area of summer tribunal							
	Floor	Walls								Weighted	Air	Floor	Ceiling	Walls				Weighted	Avg air
		N high	N low	S high	S low	E high	E low	W high	W low	average	speed			North	South	East	West	average	speed
08:30	-	-	-	-	-	-	-	-	-	-	-	27.8	27.8	26.8	27.8	28.1	28.2	27.8	-
08:35	25.3	24.4	23.8	24.4	25.5	22.2	24.1	22.2	24.1	25.4	0.7	25.0	24.7	25.0	24.0	24.0	24.3	24.5	0.7
11:30	38.7	26.2	26.0	29.7	31.1	27.0	27.0	27.0	27.0	34.7	0.9	25.9	25.8	27.0	25.7	26.5	25.8	26.1	0.9
12:30	48.4	31.7	-	33.5	-	30.1	-	30.1	-	41.7	-	26.0	26.0	27.2	26.5	26.0	26.0	26.3	-
15:30	44.0	25.8	26.5	28.6	32.4	29.8	33.5	29.8	33.5	37.4	1.5	25.0	24.6	25.5	25.2	24.8	25.2	25.1	1.5
18:30	30.0	23.1	24.0	23.0	26.8	30.0	30.0	30.0	30.0	27.9	1.6	26.9	26.9	25.7	26.5	26.9	27.2	26.7	1.6
22:30	21.6	18.6	20.7	20.4	22.3	20.9	22.7	20.9	22.7	21.2	1.6	-	-	-	-	-	-	-	1.6

5. FIELDWORK RESULTS

5.1. The Serail

Air temperature was recorded for three summer days that were representative of the typical summer conditions. Rooms with dataloggers are marked in Figure 8. Surface temperatures and air speeds were retrieved on the 29/07 and 30/07, at the times that the building was accessible. Results for air and surface temperatures are shown in Figure 24. It is to be noted that windows were closed most of the time for security purposes, though the door was open when visits were allowed. Punctual window openings are also shown in Figure 24.

5.1.1 Air temperatures

Outdoor temperatures ranged from 20ºC at night to 27-30ºC during the day, following even hotter preceding days (up to 32ºC the day before). During daytime, peak temperatures remain relatively hot between 11 and 17h. Indoors, temperatures remained remarkably stable, between 27.5 and 30.0°C, within the comfort range.

In the summer tribunal, air temperatures were the most stable of all measured spaces, with an average of 27.7°C (between 27.5 and 28.0°C throughout) and a standard deviation of 0.2°C, due to the heavy thermal inertia. It is the only space where temperatures were systematically below its immediate outdoor surrounding during daytime (except on the 31/07 when outdoor temperatures were particularly low). When all windows were punctually opened as an experiment, the air temperature dropped by 0.3K.

The winter tribunal recorded the highest temperatures of all measured spaces, ranging from 28 to 30°C, with an average of 29.0°C, and with a daily amplitude of 1.0°C, also among the largest observed. This space responded more rapidly to solar gains, as during daytime, it took on average 6.5 hours for the air temperature to increase by 1K and showed a longer nighttime drop (12h to decrease 1K). This reduced thermal stability is likely due to the smaller volume and the marquetry cladding, which partially decouples the interior from the thermal mass.

5.1.2 Surface temperatures

Surface temperatures (Table 1) were also very stable, ranging between 25 and 27ºC day and night, though reaching 24-28ºC punctually, with a normal difference of 1K between all surfaces. Opening the windows in the summer tribunal made all surface temperatures drop by 2K. The drop was much more pronounced in the judgment area (-3.5K), as more exposure to wind unloaded faster the masonry. In the summer tribunal, this represented 1 to 2K less than air temperature at all times, resulting in operative temperatures around 0.8K lower, still within comfort. In the winter tribunal, this represented 2.5 to 5K less than air, with operative temperatures 1.5 to 2K lower than air.

5.1.3 Wind speeds

In the courtyard, wind speed was usually 0.5 to 1.5 m/s, though around 1m/s most commonly. The air entered via the iwan which had slightly higher speeds. In the waiting area of the summer tribunal, the mean speed was 0.3 m/s, whereas in the judgment area it was normally 1.5 m/s, and very often it would rise to 3 or 4 m/s. In the winter tribunal, common air speed was around 0.6 m/s.

5.2. Beiteddine

Six dataloggers were placed in the rooms signalled in Figure 17, starting one day before than in the Serail. Results for air and surface temperatures are shown in Figure 25. Windows were also mostly closed for security purposes, though they open them in the morning when the palace opens.

5.2.1 Air temperatures

Exterior temperatures measured in the garden (and in the gallery) differ greatly to those measured in Deir-el-Qamar, as they remained 3 to 4ºC lower during daytime. In Beiteddine, recorded temperatures were every day lower: the first day was the hottest with a peak of 28.3ºC, the second fell to 26.3ºC, and then the peak fell some 0.5K a day until the last day that recorded 24ºC. At night, temperatures remained similar to Deir-el-Qamar.

All interior spaces show relatively stable air temperatures, with daily swings ranging from 0.5 to 2°C, remaining consistently within comfort (EN 16798). However, absolute temperatures differ substantially between spaces and are almost always above outdoors.

In the ministers' reception hall, temperatures ranged from 26 to 28°C, with an average daily swing of 0.6K. During the day, temperatures were 1 to 2.5K above outdoors, though on the first day indoors remained 1K below, reflecting the inertia of the room. Even if the thermal response is slow, the temperature still reacted slightly to outdoor variations, as it fell on average 0.2K a day. Surface temperatures at 14:00 averaged at 24.5°C, some 2K below air temperature, which accounts for the perceived coolness. Operative temperature resulted in approximately 25°C.

The Salamlek recorded the highest temperatures, ranging from 27°C to nearly 31°C; and the greatest daily swing, averaging 1.1°C. Daytime air temperatures are regularly 3 to 4.5K above outdoors, and on average 2K hotter than the minister´s room. However, the more outdoor temperatures were hot, the more the temperatures in the Salamlek were hotter in comparison: the first day the difference with the minister´s room reached 3K and the last 1.5K. Besides, on the hottest day, when temperatures were already high, direct sun penetrated the

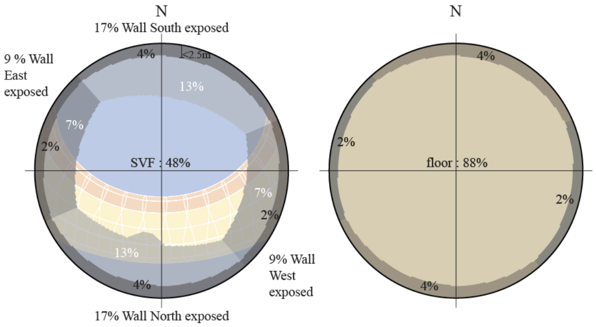

Figure 26: Shading masks and contribution of radiative surfaces

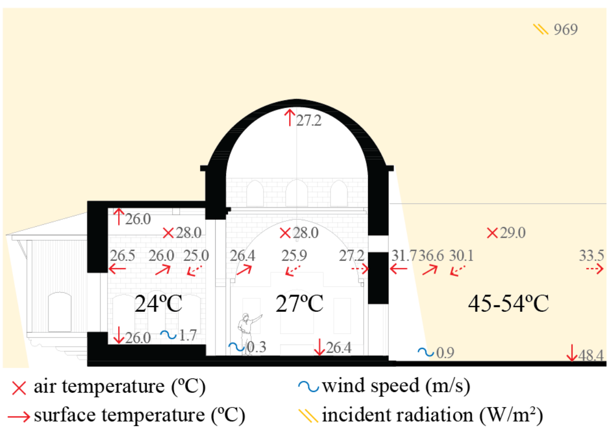

Figure 27: Summer tribunal and courtyard of the Serail Spot measurements at 12.30 and resulting PET

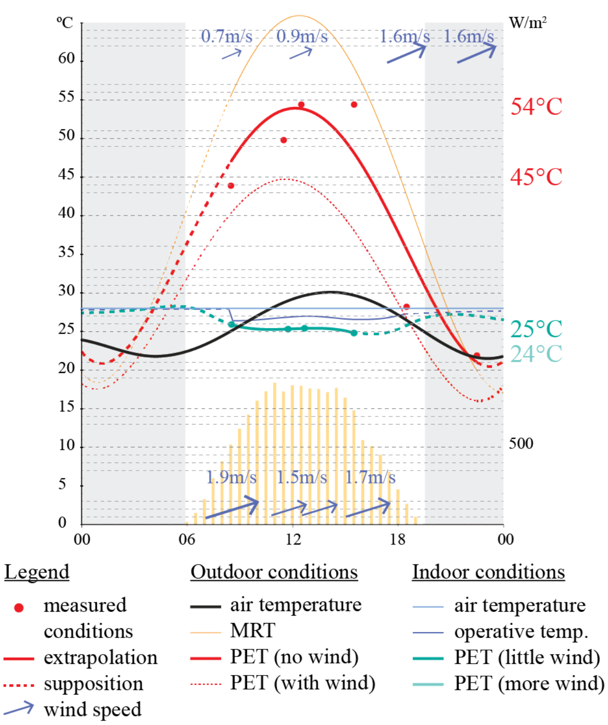

Figure 28: PET on a typical summer day indoors and outdoors

Salamlek, increasing temperature punctually by some 0.7°C at around 17:00. It was actually the only space in Beiteddine that recorded higher temperatures than the outdoor conditions of Deir-el-Qamar. Surface temperatures at 14:00 showed a weighted mean close to air temperature (28.5°C), indicating that mean radiant temperature did not modify perceived temperature at that moment. The difference in operative temperature with the minister´s room at that specific time was 3.5K, which is significant. The feeling of heat can be explained by the elevated air temperature alone, though reinforced by the lack of effect of the walls ´radiative cooling effect.

The hammam was steadily 0.5°C cooler than the ministers' reception room, with air temperatures ranging from 25 to 27°C and an average daily swing of 0.4°C, reflecting the higher amount of inertia present in the envelope. Surface temperatures at 14:00 showed a weighted mean of 25.1°C, approximately 0.7°C below air temperature.

The storage caves recorded much lower air temperatures, with a mean of 23.2°C and a standard deviation of 0.1°C. Surface temperatures measured at 14:00 were between 20 and 21°C, reflecting the large thermal lag between the ground-coupled structure, the interior air, and outdoor conditions.

A pattern clearly emerges: the coolest spaces are also the most stable, and the hottest are also the most variable; reflecting the effect of the quantity of thermal inertia each room has, and its outdoor and solar exposure.

6. THE SPECIFIC CASE OF THE SUMMER TRIBUNAL: ANALYTIC WORK

To go beyond the air temperature data and characterise the full thermal experience within the summer tribunal, an analytical study was undertaken using computational tools to calculate Mean Radiant Temperature and Physiological Equivalent Temperature, and to quantify the contrast with conditions in the adjacent courtyard.

Inside the summer tribunal, the combined effects of surface temperatures and air movement significantly influence thermal sensation. These conditions contrast with those in the sun-exposed courtyard, where occupants are subject to direct solar radiation and heated surfaces. This transition further enhances the sensation of thermal relief upon entering the summer tribunal. To characterise this effect, an analytical study was undertaken.

6.1 Mean Radiant Temperature in the courtyard

Outdoors, thermal sensation is driven primarily by Mean Radiant Temperature. In the courtyard, the central point is studied at 1.1 m height; the shading mask is used to visualise the radiative contribution of each surrounding surface (Figure 26). The floor accounts for 44% of the MRT, the walls for 32%, and incoming sky radiation for approximately 24%. Using all measured surface temperatures, MRT was calculated across a typical summer day (Figures 27 and 28). Direct sun already raises MRT above 50°C in the morning, reaching a peak of over 65°C at midday.

6.2 P.E.T.

Combining measured air temperatures, surface temperatures, and wind speeds, PET was calculated for a typical summer day at the centre of the courtyard and inside the summer tribunal. Although outdoor air temperature swings from 20°C to just above 30°C and indoor air remains nearly constant at 28°C, the perceived thermal conditions differ greatly between the two environments.

The contrast is particularly striking at midday, when air temperatures are almost identical, approximately 29°C outdoors and 28°C indoors. In the courtyard, high surface temperatures drive MRT well above air temperature, producing extreme perceived heat even in shade. In full sun, PET reaches 54°C with no wind, and 45°C with a 0.9 m/s breeze. Indoors, surface temperatures range from 24.6 to 27.2°C, with lower values in the judgment area, reducing MRT and bringing operative temperature down to approximately 27°C. In the judgment area, the breeze at 1.7 m/s further reduces PET to approximately 24°C (and when wind blows a bit stronger, to around 23°C), very pleasant for a hot summer day. The window seat, where air speeds are highest and surrounding surface temperatures lowest, represents the most thermally refined position in the building: a difference of more than 20°C in perceived temperature compared to the sunlit courtyard a few metres away, achieved entirely through passive means.

7. DISCUSSION

The fieldwork results across both buildings, taken together, allow several conclusions to be drawn, both about the effectiveness of this architectural tradition and about the conditions under which its qualities are enhanced or diminished.

Effectiveness of traditional architecture. The first point to highlight is the effectiveness of this architecture in maintaining stable (0.5°C daily swing), comfortable air temperatures (27.5-28.0°C) day and night during summer, remaining below outdoors at peak times. This high level of stability suggests that even when outdoor temperatures rise to 32–36°C, indoor air temperatures would be maintained in most of the spaces. In addition, night-time window opening could further reduce temperatures.

The means. The second point concerns the means by which this architecture achieves summer comfort. These are identifiable, cumulative, and replicable: thick walls providing substantial thermal inertia, minimised solar exposure, and controlled openings. Consistently lower surface temperatures indicate that inner wall temperatures remain fresher than air and are little affected by solar input, even when windows are open. This combination produces operative temperatures consistently below air temperature.

Nuances and limits. The third point concerns the range of conditions this architecture can produce, which is particularly revealing in Beiteddine. Two variables emerge as controlling: the degree of thermal mass and the degree of outdoor and solar exposure, and their combined effect is directly legible in the measured temperatures:

-The storage caves represent the extreme of maximum mass and minimum exposure, which results in a near-perfect stability at a mean of 23.2°C.

-The ministers' reception represents the most common space type as it lies within the building mass, protected from the sun by orientation and by a gallery, has common window sizes, and common wall thickness. This combination results in only 0.6K daily variation with moderate temperatures ranging from 26 to 28ºC. The comparison with the hammam is revealing, since it has no windows and higher inertia in the vaulted roof: the mean temperature in the hammam is only 0.7K below the minister´s reception room, with a daily variation of 0.4K. More inertia and less exposure stabilised and cooled further the temperatures, but not in a drastic manner. Airtightness in this context appears to regulate more vapour than temperature, as its absence in the minister's room adds very little in terms of heat gain or variability.

-The Salamlek sits at the opposite end: 5/6 envelope elements exposed, the thinnest walls of all measured (0.7m), the largest windows, and plenty of solar exposure, specially towards the south and west (the orientations receiving the sun when the climate is already warmed up). Every parameter that elsewhere contributes to more stability is here less favourable, which is entirely consistent with it being the hottest and most variable space in the complex.

The importance of parameters beyond air temperature. The fourth point is that architecture can shape thermal experience well beyond what air temperature alone reflects. An adequate management of surface temperatures, solar radiation, and air movement can produce dramatically differentiated conditions. In the specific case of the Serail, despite nearly identical air temperatures at midday indoors and outdoors, PET differed by approximately 30°C in full sun without wind, and by around 20°C with wind exposure. This difference is drastic, and much wider than differences observed in air temperature, which strengthens the importance of parameters other than air.

Target spaces. Fifth is the importance of concentrating some means in specific, permanently occupied spaces. In the Serail, this materialises in the strategic openings of the *liwan* and the judgment area, two specific positions within a much larger building, which benefit from a continuous air movement, as wind speeds were most of the time above 1.5 m/s, and commonly reaching 4 m/s. The result in the judgment area is a PET of 23–24°C, while a few metres away in the sunlit courtyard it reached 54°C.

The cost of transferred form. The protrusion of the Salamlek in Beiteddine closely resembles the projected volume of the summer tribunal. However, this formal import, without the finer climatic adjustments that made the original effective, resulted in measurable adverse consequences:

- higher internal temperatures: mean air temperatures 3 to 4°C above outdoors in Beiteddine during the day, against the lower temperatures of the summer tribunal which remained at or below its immediate outdoor surroundings.
- greater daily variability and susceptibility to outdoor conditions: ±1.1°C in the Salamlek against ±0.2°C in the summer tribunal. This suggests that on a day with outdoor temperatures of 34°C, the summer tribunal would likely hold around 28°C, while the Salamlek could reach 34°C or above.
- higher perceived sensation. The lower surface temperatures and the air movement in the summer tribunal lower even further perceived sensation to 23-24ºC, whereas in the Salamlek the convergence of surface and air temperatures, combined with the absence of cross-ventilation, could maintain perceived temperatures close to air. On a 34°C day, the thermal perception in the Salamlek could remain at 34°C, or even more, a total difference between the perceived sensation of up to 10ºC.

Strikingly, the Salamlek and the winter tribunal of the Serail recorded similar temperatures: the room that was intended to echo the most climatically refined space in the region performs, in summer, like a room designed for winter. A typology, transplanted without its logic, produced the opposite of its intended effect.

Living with the climate. At all scales, interior nomadism offers a way of inhabiting climate rather than suppressing it, embracing thermal variation as a design tool rather than working against it. In the Serail, this is expressed seasonally: the summer tribunal is precisely tuned for summer and recorded the most stable and comfortable conditions during the fieldwork, while the winter tribunal, where the highest temperatures were recorded, is optimised for winter use, its configuration reversing almost every parameter of its counterpart. The measured temperature difference between the two spaces is the direct, quantifiable consequence of their opposing configurations. In Beiteddine, the rhythm is daily. Formal audiences take place in the cooler morning hours; the afternoon heat is met by moving outdoors, where the palace site is measurably cooler than the surrounding landscape; the late afternoon, when in summer it can be very hot or in winter very cold, time is spent in the hammam, where the baths can help to rebalance the body temperature.

The power of perception. Some elements shape the experience of a space without measurably altering its conditions. Just as firelight reflected in the marquetry of the winter tribunal reinforces the perception of warmth, the fountain in the antechambers of Beiteddine contributes to a sensation of freshness through direct sensory contact with water. Perceived comfort is not reducible to measured temperature alone, and the climatic intelligence of this architecture extends to dimensions that instruments cannot fully capture.

8. CONCLUSION

Beyond their cultural and historical value, these buildings remain exemplary models in delivering summer thermal comfort, offering lessons from both their shared principles and their nuanced, context-specific strategies.

The analysis showed that natural temperatures consistently within comfort were the direct result of identifiable architectural decisions: thermal inertia, controlled solar exposure, volume and façade exposure, and sometimes targeted ventilation. These operate cumulatively and can be replicated. These means contrast with the dominant contemporary approach, which relies on airtightness, insulation, and mechanical air control; particularly in meeting spaces, which was precisely the function of these rooms.

Interior nomadism adds a further dimension, using the differentiation of spaces as a means of inhabiting climate rather than suppressing it.

Together, these strategies show us again that a precise knowledge of climate, translated into architectural form, can be a more effective means of achieving thermal comfort than working against it.

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