WATERMILLS ON IBIZA (BALEARIC ISLANDS). A DOCUMENTARY AND ARCHAEOLOGICAL CASE STUDY IN SANTA EULÀLIA DES RIU[1]

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Abstract: This paper focuses on hydraulic systems located on the Santa Eulària river and Ierns torrent (Santa Eulària, Ibiza). The research identifies the original Andalusi systems and later expansions, as well as giving a description of their technical features (channels, secondary channels, derivation dams, watermills). A number of watermills were identified through the written records generated by the Christian conquest (1235) and the archaeological survey. A great expansion of the systems from the 18th century onwards has been attested. In 2009, the opportunity arose to undertake the archaeological analysis of the building which hosts one of the watermills in the Santa Eulàlia valley. This watermill is known as Molí de Dalt (Upper Watermill) and is located in the Canal Antic (Old Channel), also called Canal des Molins (Channel of the Watermills). It has been possible to describe several phases of building and technical changes from Andalusi times to the 20 century.
Keywords:

Introduction

Between 1992 and 1998, a research program directed by Miquel Barceló analysed settlement and cultivation patterns on Ibiza during the Andalusi period.[2] This program began in the 1980s as a part of a broader project on the archaeology of the Balearic Islands.[3] The programme involved the analysis of 48 irrigation areas, which were identified as having an Andalusi origin on the basis of their association with nearby archaeological sites, certain toponyms and written references.[4] The areas under study included the hydraulic systems located along the lower course of the Santa Eulàlia River and its affluent the torrent of Es Ierns.

Most of the river valley is currently situated within the municipality of Santa Eulàlia des Riu. Prior to the division of the territory into municipalities, which took place in the 19th

[1] This research is supported by the Research Project, *Órdenes agrarios y conquistas ibéricas (siglos XII-XVI). Estudios desde la arqueología histórica* (HA2017-82157-P) funded by the Spanish Government's Plan Nacional de I-D-i.

[2] See its major accomplishments: Barceló, *El curs de les aigües*; Barceló, González, and Kirchner, 'La construction d'un espace agraire drainé'; Barceló, 'Immigration berbère'; Kirchner, 'Tierras de clanes'; Kirchner, 'El mapa de los asentamientos', pp. 120–86; Kirchner, 'Migración y colonización'.

[3] Barceló, and others, *Les aigües cercades*; Kirchner, *La construcció de l'espai pagès*; Sitjes, 'Inventario de sistemas'; Barceló and Retamero, *Els barrancs tancats*.

[4] Kirchner, 'El mapa de los asentamientos'; Kirchner, 'Migración y colonización agraria'.

century, the area was known as Quartó de Santa Eulàlia or Quartó del Rei (the King's Share). *Quartó* was the word used to refer to each of the jurisdictional districts the island was divided into after the Christian conquest in 1235. To some extent, this division followed the previous territorial structure. Thus, the Quartó de Santa Eulàlia corresponded to the Andalusi district of Šarq ('orient', 'East' in Arabic).

The hydraulic systems located in the lower course of the Santa Eulàlia River were in use until the mid-20 century. The research programme undertaken resulted in the identification of the perimeter of the original Andalusi systems and later expansions, as well as in the description of its technical features (channels, secondary channels, derivation dams).[5] There were four Andalusi irrigation systems, two on the torrent of Es Ierns and two on the Santa Eulàlia River. A number of watermills were also identified, partially through the records generated by the Christian conquest. The study also attested the expansion of the systems from the 18th century onwards.

In 2009, the opportunity arose to undertake an archaeological analysis of the building which hosts one of those watermills which is known as Molí de Dalt (Upper Watermill) or Molí de Can Planetes. It is located on the Canal Antic (Old Channel), also called Canal des Molins (Channel of the Watermills) on the left bank of the Santa Eulàlia River. This research made the Interpretation Centre of the Santa Eulàlia River possible, newly created in the watermill and the adjacent house.

Historical context: the Oriental Islands of al-Andalus[6] and the Catalan conquest

Before their actual occupation in AD 902 (AH 290), the Balearic Islands had already been the target of a number of military expeditions.[7] However, there is no mention of Ibiza in any of the chronicles that describe these expeditions and there is close to no archaeological evidence, several numismatic finds excepted, that can be confidently dated to between the 7th and 10th centuries on Ibiza.[8] In fact, it is possible that there was a significant population decline during this period, to the extent that the Andalusi chroniclers saw no need to include Ibiza in their description of the pacts.[9]

After the mid-9th century AD, the islands were not mentioned by Arab sources until the official conquest by ʿIṣam al-Jawlānī in AD 902 (AH 290).[10] Although these sources only mention the island of Majorca, tribal groups from Šarq al-Andalus (eastern part of al-Andalus) emigrated to all three islands. Since Ibiza is geographically the closest to the Iberian

[5] Derivation dams, *azud* in Spanish, from the Arabic *as-sud*: normally these are simple structures built with non-perishable and perishable materials (stone, timber, mud and plants), which elevate a water course and direct it towards an artificial channel.

[6] Name used by the Andalusi chroniclers to refer to the Balearic Islands.

[7] Guichard, 'L'intégration des Baléares', p. 59; Barceló, *El curs de les aigües*.

[8] Retamero, *Moneda i monedes àrabs*; Retamero, '*Fulūs* y moneda'; Ramon, *El Baix Imperi*, pp. 24–26; Ramon, 'L'Antiguitat Tardana', p. 495; Ramon, 'La cerámica ebusitana', p. 565; Gómez, Díes, and Marí, 'Tres paisajes ibicencos', pp. 110–15.

[9] Barceló, *El curs de les aigües*.

[10] Barceló, *Sobre Mayūrqa*, p. 9.

Peninsula, it must also have functioned as a stopover point for those going to Majorca and Minorca.[11]

The homogeneity of the settlement patterns and the technology employed in the construction of the irrigation systems suggests a brief colonisation process.[12] According to Barceló, the possibility of colonising the islands was not considered until the activities of the *baḥriyyūn* provided the necessary information and the naval requirements were met.[13] The *baḥriyyūn ahl al-Andalus* ('sailing people from al-Andalus', who were usually organised tribally) established several naval bases on the Western Mediterranean coasts and Crete, as described by the Carolingian chronicles.[14]

The technical and agricultural knowledge already acquired on the Iberian Peninsula played an essential role in the occupation of land for cultivation, grazing, hunting and harvesting.[15] The associated skills included the levelling of channels, the implementation of water distribution techniques, the construction of terraces and the creation of valley-bottom field systems, the building of watermills, the operation of different systems for collecting water, either through natural sources, *qanāt*(s) or water lifting devices, the application of cultivation techniques and the utilization of precise crop combinations.[16] The new colonists preferred irrigation agriculture, but alternative or supplementary survival strategies such as stockbreeding and dry-land agriculture were also crucial. Dry-land agriculture was preferably done on the edges of marshes and in valley-bottoms.[17] The spatial choices made by the new colonists are, in consequence, an important clue to understanding the process of colonisation.[18]

The settlement pattern is characterised by the presence of interconnected rural settlements which were spatially linked with the agricultural areas. Many place names are of Berber origins, but Arab names may also be found. On Ibiza, however, all toponyms seem to be of Berber origin.[19] They are mentioned in the Catalan documentary sources as *alqueria* (Arab *qarya*) and sometimes as *rafal* (Arab *raḥl*). The *alqueria* refers to a territory which can include more than one residential area and more than one cultivation area. *Rafals* were supplementary agricultural areas linked to the *alquerias*.[20] These settlements were organised in networks which are the result of agricultural land selection criteria.

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[11] Barceló, 'Immigration berbère'.

[12] Barceló, 'Immigration berbère'.

[13] Barceló, 'Immigration berbère'.

[14] Barceló, *Sobre Mayūrqa*, p. 39; Moll, 'Historia política de las Islas Orientales'; Guichard, 'L'intégration des Baléares'.

[15] Barceló, 'Immigration berbère'.

[16] Glick and Kirchner, 'Hydraulic systems and technologies'; Barceló, 'Immigration berbère'.

[17] Retamero, 'On dry farming in al-Andalus', in this volume.

[18] Research on large regions of Majorca, Minorca and Ibiza indicates that settlement patterns and the layout of hydraulic systems were highly homogenous. This can be explained only by an intense and fast migration process, which would not have been possible without a well-tested economic strategy. See: Barceló and Kirchner, *Terra de Falanis*; Argemí, 'El sistema de molinos'; Argemí, *A la recerca de la lógica;* Argemí, *A les vores dels torrents*; Barceló, *El curs de les aigües*; Kirchner, *La construcció de l'espai pagès*; Kirchner, 'Tierras de clanes'; Kirchner, *La ceràmica de Yābisa*; Kirchner, 'El mapa de los asentamientos'; Barceló and Retamero, *Els barrancs tancats*; Barceló, 'De la congruencia y la homogeneidad'; Barceló, 'Immigration berbère'.

[19] Barceló, *El curs de les aigües*; Barceló, 'Immigration berbère'.

[20] Kirchner, 'Original design'.

On all three islands (Majorca, Minorca, Ibiza), streams were the main communication axes, and also a central factor in the distribution of settlement networks. The map of Ibiza (see Map 1) shows that most irrigation areas were concentrated in the main river basins. These include the basin of the Santa Eulàlia River and the torrent of Ierns, located on the eastern side of the island, the streams of Xarraca, Benirràs, Sant Miquel de Balansat and Es Rubió, which flow across the northern part of the island, the streams of Canal de Fruitera and Llavanera, which run into the bay of Ibiza, the stream of Buscastell, which flows into the bay of Portmany (Sant Antoni), in the western part of the island, and a number of smaller streams that run to the southern coast (S'Aigua, Cas Berris-Ses Fonts, Es Cirer-Sa Font). [21]

Map 1.

On Ibiza, we find the two basic types of irrigated areas typical of rural Andalusi settlements: those built on a valley bottom and those built on a hillside or slope.[22] Good examples of the former may be found in Buscastell, the torrent of Ierns, Santa Eulàlia and Labritja. This type accounts for 60% of the irrigated land on the Balearic Islands.[23] Examples of the latter are found in Balansat or in very small irrigated areas (<0.5 ha) in the valleys of Xarraca and Benirràs. There are 31 irrigated areas in valley bottoms and 17 on hillsides. The average size of the irrigated areas on the Balearics was relatively small, c. 1 ha per hydraulic system.[24]

On Majorca, as well as on Ibiza, mills were often concentrated in the largest hydraulic systems, which were normally associated with the larger *alquerias* or shared between a number of smaller settlements. The most common way of integrating mills into the irrigated areas was to place them on the main canal, so that the mills could use the water running through the canal, and return it back to it. On Ibiza, the main clusters of mills are at Buscastell, Balansat and Santa Eulàlia.[25]

Ibiza and Formentera were conquered by Guillem de Montgrí, the sexton of Girona and archbishop elect of Tarragona, Nuno Sanç, Count of Roussillon and Cerdanya and Peter, Prince of Portugal, in the summer of 1235. The Chronicle of King James I, who was himself absent, is the only document to give any details of the actual fighting. According to this chronicle, the attackers besieged the only city on the island and the defenders surrendered on 8th August.[26]

The distribution of the island was recorded immediately after the conquest in the document known as *Memoriale Divisionis*, that is the local version of a repartiment document.[27] The *Memoriale* describes the boundaries between the pre-conquest districts, as well as the names

[21] Kirchner, 'El mapa de los asentamientos'.

[22] Glick and Kirchner, 'Hydraulic systems and technologies'.

[23] Sitjes, 'Inventario de sistemas hidráulicos'.

[24] Sitjes, 'Inventario de sistemas hidráulicos'.

[25] Kirchner, 'Watermills in the Balearic Islands'. There were no watermills on Minorca in the Andalusi period, but much archaeological evidence exists for the use of manual mills. Sánchez Navarro, 'Estudi de les pedres'.

[26] Jaume I, *Llibre dels fets del rei en Jaume*, p. 100–01.

[27] Marí, *La conquista catalana.* The *repartiments* (literally 'distributions') were the documents that allocated newly conquered lands and rents among the king and the nobles who had taken active part in a successful campaign against al-Andalus. Guinot and Torró, *Repartiments a la Corona d'Aragó*.

and number of hamlets (*alquerias*), farmhouses (*rafals*) and watermills. As the document clarifies, the boundaries between districts were based on information provided by the *'al-mušrif* (tax collector) of the land, advised by other Saracens'.[28] The changes in the boundaries of the Andalusi districts brought about by the feudal distribution were also recorded in the same document.

The evidence concerning what befell Muslim people is not particularly abundant, and namely consists of an allusion to unconditional surrender in the previously cited chronicle. Everything seems to suggest, therefore, that, as had happened previously on Majorca and was also to happen on Menorca in 1287, the Muslim population of Ibiza was reduced to captivity.[29]

The rural territory of the island was divided into four parts. Previously, in Andalusi times, there were five administrative districts. Guillem de Montgrí was granted two parts: Benizamid, from the Arabic Banū Zamid, which was soon afterwards renamed Balansat, after one of the local hamlets, and Algarb, from the Arabic al-Garb ('the west'), later known as Les Salines. The district of Xarc, from the Arabic *šarq*, later named Santa Eulàlia, was granted to Peter of Portugal, and Portmany to Nuno Sanç. The fifth Andalusi district corresponding to the territory situated in the immediate vicinity of the *madīna* and was known as Alhaueth (from the Arabic *al-ḥawz*) was also divided into four parts, each of which was assigned to one of the four new districts.

The only urban nucleus on the island, Madīna Yābisa, was distributed among the three conquerors on a house-by-house basis.[30] The sea salt-producing area situated within the district of al-Garb was left undivided, in order for its productive unity to be maintained. The agreement established that the annual salt yield was to be divided into four parts, two for Guillem de Montgrí, and one for each of the other two overlords.

Flour mills were an important part on the conquered land because of their potential for raising rent. Accordingly, the *Memoriale Divisionis* mentions fifteen such facilities. They were identified by the name of their last Andalusi owner, although they had died, been taken captive or fled. Each overlord was allocated a number of mills, not all of which were located in their respective districts. We shall discuss below if our object of study, the Molí de Dalt, was one of these watermills enumerated in the first document written after the conquest of the island. We can advance that the combination of the archaeological and documentary approach allowed us to propose a positive answer.

Methodology

The methodology employed for the study of the watermill called Molí de Dalt and the hydraulic system of which it was a part combines several techniques and sources of information: research in the written record, the mapping of the hydraulic systems, the

[28] Marí, *La conquista catalana.* The *almojarife* (from the Arabic *al-mušrif*) were the officials in charge of public tax collection. Guichard, *Les musulmans de Valence*, p. 259.

[29] Soto, 'La situació dels andalusins'; Soto, '¿Una oferta sin demanda?'; Jené, 'La conquesta de Manūrqa'; Ferrer, 'Captives or Slaves'; Ferrer, 'Captives at the conquest'.

[30] Marí, *La conquista catalana*.

excavation of the interior of the building and the architectural analysis of the standing structures.

A large written record between the conquest and very recent times has been examined. The aforementioned *Memoriale Divisionis* has already been noted as the earliest document in which the watermills are mentioned. The other fundamental documents are the records of the legal standing of properties over time, called *capibrevia* in Latin, which were elaborated between the 13th and 18thth centuries. Generally, the documents refer to the manager of the watermill, who is understood as the tenant in possession of the *dominium utile* (the right to effective possession in exchange for a rent paid to the holder of the *dominium directum*, the lord). This practice could involve a superimposition of rights-holders, thus creating several middlemen between the miller, who was the person who effectively ran the mill, and the ultimate owner. This is why a single mill can be referred to with different denominations.

In addition, millers changed frequently. Generally, they were members of the local elites, people engaged in diverse economic activities which included the management of watermill-related rents. Watermills were, just as any other economic asset, subject to a degree of speculation, which explains the frequent changes of management. Most commonly, each transaction involving the *dominium utile* was followed by a change to the denomination of the watermill. This is especially the case concerning accounts and fiscal documents, such as *capibrevia* or rent relations. In other documents, for example wills, inventories and sales contracts, the tendency was to use the watermill's most popular denomination and not to focus so much on the tenant. This variability makes the identification of specific watermills more of a challenge. These 'other', toponymic names are generally based on the characteristics of the watermill, its surroundings or its position in the hydraulic system (big mill, small mill, upper mill, lower mill, middle mill, etc.).

Thus, it is not unusual to find the same mill named in different ways: with the name of the lord in possession of the *dominium utile*, the name of the miller or the popular name. The comparison of the rents and boundaries given in the documents can facilitate identification. At any rate, all of these records must be used in combination, which is a laborious, but also potentially more fruitful approach, than trusting one kind of document alone. Cases such as the one at hand, in which several watermills can be found within a relatively small area, make it imperative to follow the legal track of each watermill as far as the documentation permits.

The hydraulic systems of the Santa Eulàlia River and the torrent of Ierns were mapped following the 'hydraulic archaeology' methodology. The specificity of hydraulic archaeology results from the peculiarities of its own subject matter, the irrigated areas, the key principles of which were defined by M. Barceló.[31] This methodology can also be applied, with slight modifications, to other agricultural or grazing areas. The methodology's main tool is the creation of a detailed, survey-based, map of hydraulic networks. After the survey, the irrigation networks and distribution of agricultural fields must be compared with the information provided by the written record. Often, the original irrigation systems were expanded at a later date, which makes it necessary to go beyond the medieval records and examine modern and contemporary documents as well. A morphological analysis of the field layout is very revealing for the phases of construction. Finally, a generic archaeological survey must be carried out around the cultivation areas. It is not rare for medieval irrigation

[31] Barceló, 'El diseño de espacios'; Barceló, 'De la congruencia y la homogeneidad'.

systems to be found in association with Andalusi settlement sites. This methodology has mostly been applied to Andalusi irrigation systems, but it has also been used for feudal hydraulic systems in the Iberian Peninsula and Yemen.[32] Concerning watermills, hydraulic archaeology allows them to be studied not as isolated structures but as part of a larger hydraulic system which involves water catchment and channelling and mechanical solutions based on gravity, which are consistently neglected in the written record.

The analysis of the Molí de Dalt included the structural analysis of the extant architecture and the excavation of the interior of the building. This type of intervention, which is now common, was initially systematised by E. C. Harris and later refined primarily by British and Italian archaeologists.[33]

The building was completely whitewashed with lime mortar. In order to expose the structure, c. 0.6 x 0.4 m archaeological cuts were made in the mortar of the walls, at a height of approximately 1.5 m. These cuts were positioned so as to expose the structures as efficiently as possible with the precise position determined following an initial structural analysis. Each layer of lime mortar or sand was given a stratigraphic number. Once the structure had been exposed, the different features were also given stratigraphic numbers.

The analysis allowed for the identification of the constructive sequence, from the oldest phases to the most recent. However, the methodology described can rarely go beyond a relative chronology of construction phases. In order to obtain some absolute chronologies to these different phases, it was necessary to analyse the written record.

The excavation of the interior of the building also had some limitations because the watermill was in operation between the Middle Ages and the mid-20 century. Hydraulic systems are generally stable and to some extent rigid, which essentially forced the watermill to stay in its original location. At the same time, structural renovation and more or less radical mechanical innovations, have always been integrated into the same structure. This means that the original features have disappeared almost completely. In addition, since the watermill is quite small (30 m^2 in its latest and lengthiest phase), the impact of structural changes was greater. The latest transformation involved the replacement of a vertical penstock and a horizontal wheel with a vertical wheel; this, therefore, involved the removal of the penstock, the tail-race and the northern half of the milling area. The excavation showed that the rubble from the demolition was used as a backfill. The fill was, however, devoid of material, ceramic or otherwise, which could have been used to date this phase. It could be said that the hopes placed in the archaeological survey have been disappointed by the effects of the continuity of use of the watermill over the centuries.

In conclusion, excavation revealed the sequence of structural changes undergone by the watermill over time and the technical features of each phase, but it was impossible to assign a chronology to these stages. As we shall see, however, the written record provides evidence for the dating of some of these structural changes.

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[32] For Andalusi irrigation systems, see bibliography cited above. For feudal irrigation systems, see: Batet Company, *L'aigua conquerida*; Kirchner, 'Conquista y colonización'; Kirchner, 'Hidráulica campesina'. For work carried out in Yemen, see: Barceló, 'The search for the Hararah *asdad*'; Barceló, Kirchner, and Torró, 'Going around Zafar'; Barceló and Torró, 'The hydraulic set-up'.

[33] Brogiolo, *Archeologia dell'edilizia*; Utrero Agudo, 'Archaeology. Archeologia. Arqueología.'; López Mullor, 'La construcción de un método'.

The watermills of Santa Eulàlia in the written record

As mentioned above, the *Memoriale Divisionis* enumerates a series of watermills. These were not all the flour mills standing on the island, but only those allocated to the three overlords. Since a few of those mills were outside each lord's respective district, then, it was felt very necessary to mark clearly in writing to whom each flour mill belonged and where exactly it was.

According to this, the *Memoriale* provides us with the following information about each district on the island. Six mills are mentioned in the district of Šarq: Three allocated to Peter of Portugal, the lord of that land, and three assigned to the land of al-Garb, one of the two demesnes of Guillem de Montgrí.[34] In Portmany, Nuno Sanç's district, was allocated four mills, which were in fact in the district of Banū Zamid, the other domain of Montgrí.[35] Finally, in addition to the aforementioned mills in Šarq, al-Garb was allocated another in Banū Zamid.[36] Therefore, four mills were allocated to each district, except for Šarq, which was allocated three. All the mills mentioned were in Šarq and Banū Zamid. Thus, the mills assigned to Portmany and al-Garb were located outside their own boundaries.

The *Memoriale Divisionis*, it follows, did not compile an inventory of all the mills that existed on the island in August 1235, but mentioned only those which were to be distributed among the new overlords.[37] This was later confirmed when the archaeological survey of hydraulic infrastructures noted the presence of several watermills in the districts of Portmany and al-Garb.[38]

In 1241, Guillem de Montgrí bought Nuno Sanç's part from King James I, who had purchased it from the executors of the count's will. Short time after this acquisition, Montgrí ordered a *capibrevium* of the rents of Nuno Sanç's former domain (*Capbreu Antich de Eviça*, hereafter CAE), which included the names of all tenants and the taxes due to their new lord.[39] The archdiocese of Tarragona followed suit in 1276, after the death of Guillem de Montgrí in 1273 (*Capbreu del Llibre Verd de Tarragona*, hereafter CLVT).[40] Two further *capibrevia* were issued in 1396 and 1433, by order of the archdiocese and the cathedral chapter, respectively. Both these *capibrevia* and other documents demonstrate that the pre-conquest agreement and the dispositions of the *Memoriale Divisionis* remained in force long after their original date.

Regarding the sector of Šarq (Santa Eulàlia), which eventually became the property of the

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[34] One 'which was Zaffi's' and two 'which were Benloax's', and one 'which was Dalmonya's' and two 'which were Cayz's'. Marí, *La conquista catalana*, p. 76.

[35] 'Muzalcabuzi's', 'Azmeti Abinzayt's', 'Lemogaya's' and 'Abnatale's'. Marí, *La conquista catalana*, p. 76.

[36] Marí, *La conquista catalana*, pp. 76–77.

[37] Barceló, *El curs de les aigües*, p. 38.

[38] The case of Buscastell in Portmany: Argemí, Barceló, Kirchner and Navarro, 'Un sistema hidràulic compartit'. For its current state and recent history, see: Cirer, *Buscastell*. And the case of the Torrent de ses Fonts in al-Garb: Ferrer, Graziani and Kirchner, 'Archaeological survey on a Watermill'; Ferrer, Graziani, and Kirchner, 'Estudi arqueològic d'un molí fariner'.

[39] The Latin word *capibrevium* (equivalent to the Spanish *cabreve* and the Catalan *capbreu*) is used to refer to a sort of document issued by jurisdictional overlords in order to keep a record of the duties, especially rents, paid by their vassals and tenants.

[40] Torres Peters, *Dos capbreus del segle XIII. Capbreu Antich de Eviça i Capbreu del Llibre Verd de Tarragona*.

Crown, there is a 1326 document which records the accounts of the royal lieutenant on Ibiza and mentions four watermills located there.[41] Another book, dated from 1468, which again inventories the king's property, also lists four watermills.[42] In 1577, a new *capibrevium* was ordered to assess the taxes due to the king on Ibiza.[43] This document is the earliest available in relation to the royal portion of Santa Eulàlia and the associated third the city. Detailed records for the dues and the landed properties reappear in notarial documents throughout the 17th and 18thth centuries, and also in the last *capibrevium* carried out in the royal portion of the island, which was issued in 1797.

This late 18th-century *capibrevium* was part of a broader programme aimed at increasing the Crown's revenues from the island of Ibiza.[44] This programme was designed and implemented by an Improvement Committee. One of the main aims of this was to improve agriculture. As a consequence, the area of land under cultivation increased. In addition, mechanical innovations were introduced for the machines used to process agricultural products, especially in watermills.

These were the main lines of the documentary record that had to be studied to obtain useful information about the Molí de Dalt. The *Memoriale Divisionis* was its older milestone and the 18th-century *capibrevium* was the most recent. Between both marks, different documents were located in the archives that together form the written record left by the watermill, its owners and users over the centuries.

A sales contract dated from 1266 mentions a watermill situated 'in the place known as Santa Eulàlia'.[45] The 1276 *capibrevium* (CLVT) alludes to two watermills that were the archbishop's property in this same place.[46] These were two of the three watermills assigned to al-Garb in 1235. Then, the archbishop had not only the ownership of the mills but the jurisdiction on them too. This was a source of trouble because the surrounding land belonged to the king and he had the jurisdiction over it. In 1301, a series of offences committed in the archbishop's mills in Santa Eulàlia triggered a dispute concerning whose authority it was to judge the accused: the king's or the archbishop's. The overlords had other classical rights over their vassals: a document dating from 1326 urged one of the archbishop's vassals, a resident of Les Salines (al-Garb), to mill his grain in a specific watermill in Santa Eulàlia (no doubt one of the archbishop's three watermills). In fact, this prescription was underlined by a court decision which stressed the validity of the lord's monopoly over milling.[47]

Later, the *capibrevia* inventorying the property of the archdiocese of Tarragona in 1396 and in 1433 mention a single watermill. These documents demonstrate that the 1235 assignment of watermills was still in full force, even if only one of the three former watermills

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[41] Sastre Moll, *L'exportació de sal*, p. 115.

[42] Torres Peters, 'Procuració reial d'Eivissa (1468-1470)'.

[43] Arxiu del Regne de Mallorca, Reial Patrimoni, 308.

[44] Arxiu del Regne de Mallorca, Reial Patrimoni, 315, fol. 19^{r}.

[45] Arxiu Històric d'Eivissa i Formentera, Medieval *capibrevium*.

[46] *Berengarius de Letone VIII quintars farine frumenti et VIII quintars farine ordei pro uno molendino quod habet apud Sanctam Eulaliam, in termino alquerie A. Dez Mas, et debet ferri dicta farina intus castrum et solvi in festo Sancti Michaelis medietas et alia medietas in Carniprivis; P. Celerer et R. De Serra V quintars farine ordei et V quintars farine frumenti pro uno molendino quod tenet in Sancta Eulalia et debet ipsam farinam solvere intus castrum*. Torres Peters, *Dos capbreus del segle XIII*, p. 92.

[47] Arxiu del Regne de Mallorca, Suplicacions 5, fol. 131^{r}.

assigned to Montgrí as lord of al-Garb was then in working order. We do not know exactly why the other two watermills disappear from the record, but they were probably abandoned and in ruins. Then the question arises of why that should happen.

The watermills initially assigned to Peter of Portugal, which would later become the property of Prince James, the kings of Majorca and, finally, the kings of Aragon, were in operation for longer than the archbishop's. Thus, the royal lieutenant's accounts log for 1326 mentions the dues payable by the tenants of the four watermills in Santa Eulàlia: in total, these amount to 1,200 kg of flour, one-third of wheat flour and two-thirds of barley flour. The Crown, therefore, added a fourth mill to its possessions sometime between 1235 and 1326. The royal lieutenant's accounts book dated from 1468, and the *capibrevium* issued in 1577 also list four watermills.

This latter document mentions for the first time some vegetable gardens that were near the watermills 'located in the valley of Santa Eulàlia'. The tenants of the king's mills are listed, and the boundaries of the properties where the mills stood are described. The archbishop's only mill is also mentioned. Thus, the miller Joan Tur had 'a watermill with house, vegetable garden, and houses'; Joan Mestre's watermill bordered the 'orange tree grove known as la Torre, which is traversed by a water channel', a fence and a vegetable garden that used to be a vineyard; and Antoni Rosselló's watermill bordered the channel, another watermill and the 'foot of the mount of Santa Eulalia'. A fortified church was built on this hill in the 15th century, at the latest. About 1565, the original church was replaced by a new one, with a bastion to fight with and against cannons. A 1625 document claims that the function of the church was to protect the watermills 'because most of the urban dwellers and many more from around the island mill their grain there'.[48]

Thus, a significant number of the island's watermills were concentrated in the Santa Eulàlia area, and many Ibiza city dwellers took their grain there to be milled. It is, therefore, not surprising that since the 14th century the municipality's magistrates carried out an annual inspection in order to ensure that the channels and watermills of Santa Eulàlia were 'in a sound state of repair'.[49]

The five watermills of Santa Eulàlia feature constantly in notarial documents throughout the 17th and 18th centuries, these probably being the four owned by the king and the one in possession of the archbishop of Tarragona. Of special relevance is a new *capibrevium* on the royal revenues, which was drawn up in 1797. It mentions five watermills near the Santa Eulàlia River. Of these, four have been identified beyond doubt, as they were in operation until the mid-20 century. They are known as Molí de Dalt, Molí d'Enmig, Molí d'en Marge and Molí de Baix (Upper, Middle, Marge and Lower mills respectively). The archaeological survey permitted the identification of three more watermills in the valley. The one called Can Fita was built over the channel that runs to the right of Font des lerns, an extension of the original irrigation network dating from the 18th or 19th century. This watermill was destroyed around 1990 before it could be studied. The other two watermills are older; first, Es Molinet (The Small Watermill), which closes the hydraulic system to the right of the river (the main channel and the derivation dam were also known as Es Molinet) and secondly, another watermill which closes the hydraulic system to the left of Font des Ierns, and of

[48] Ferrer, *El puig de Missa de Santa Eulàlia*, p. 117.

[49] Arxiu Històric d'Eivissa, *Llibre de clavaria de 1373–74*, fol. 3^{v}.

which a cylindrical monolithic penstock has survived. Both these watermills remain unexcavated to date. Everything indicates that these were abandoned in the Middle Ages, and it may be hypothesised that these were the archbishop's mills that disappeared from the records in the thirteenth and 14 centuries.

The earliest direct allusion to the Molí de Dalt dates from 1304, when the watermill is described in a document as 'the upper watermill'.[50] This denomination, based on the position of the mill on the course of the channel and with regard to the other watermills, facilitates its identification in earlier and later documents. The document is the will of Guillem Escrivà, owner of a half of the mill. We know that, in 1266, Escrivà bought a watermill from Margarida, the widow of the knight Pere de Cervera, who had participated in the conquest of the island in 1235. The sales contract mentions the name of the miller at the time of the transaction: Joan de Comalleres.[51] We can suppose it is the same mill that Escrivà left to his son Berenguer in his will.

Unfortunately, the Molí de Dalt cannot be clearly identified among the six mills of Šarq listed in the *Memoriale Divisionis*. If it already existed then, it must have been one of those left under the king's jurisdiction, because the 1276 *capibrevium*, concerning the revenue of the archdiocese of Tarragona, does not mention Escrivà as a tenant of either of the archdiocese's three watermills in Santa Eulàlia.

In 1422, an interesting document informs us that the watermill had been in a ruinous state for over fifty years, and that it remained in this condition until Guillem Rosselló, who was the owner of a half of the property, repaired it, cleaned the channels and put it to work once more. The document describes this watermill as the first of those owned by the king on the channel of Santa Eulàlia. Rosselló applied to the court for a remission of the rent as compensation for the effort of putting the watermill back in operation. The request was duly granted.[52] This G. Rosselló was not a nobody. According to a 1433 *capibrevium*, he lived in the upper part of Ibiza town, next to the church and the seats of the main institutions. In 1429 he bought the hamlet of Beniatzara y Beniesquerpa. In 1430, he also acquired a few houses in the city and, finally, in 1433, a rafal or country estate in Balansat, close to one of his hamlets.[53] Like other mill owners about whom we have information, for example Pere de Cervera, his widow, and Guillem and Berenguer Escrivà, Rosselló was a wealthy man.

Despite some gaps, notarial documents are a reliable source for the ownership history of the Molí de Dalt throughout the 17th and 18thth centuries. In 1797 in relationship with the elaboration of the new *capibrevium*, and an analysis of the actual producing capacity of the island, the so-called Improvement Committee appraised the five watermills in Santa Eulàlia in very negative terms, even their location was deemed to be very inconvenient. They were concentrated on the lower course of the Canal dels Molins (Mills Channel), an area where the unevenness of the terrain allowed for the installation of the vertical penstock and wheel.

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[50] *Item dimito ei medietatem illius molendini superioris quod est apud Sanctam Eulaliam*. Arxiu del Regne de Mallorca, Suplicacions 5, fol. 131^{r} and following. The name Molí de Dalt does not appear until the 19th century. Marí, *Santa Eulàlia*, p. 320.

[51] *Et totum dominium, censum, jus, faticam et laudimium que habeo et habere debeo in illo molendino quod tenet per me Johannes de Comaleres in Sancta Eulalia*. Arxiu Històric d'Eivissa i Formentera, Medieval *capibrevium*.

[52] Arxiu Històric d'Eivissa i Formentera, Medieval *capibrevium*.

[53] Torres Peters, *El capbreu dels arquebisbes de Tarragona Gonçal Ferrandis d'Híxar i el cardenal Domènec Ram (1433-1437)*, pp. 78, 89, 93, 106 and 121. We wish to thank Torres for providing us with the transcription of the document.

Their position, therefore, was adapted to irrigation, which was the main function of the channel. The committee proposed moving them up the course of the channel and placing them next to the derivation dam. This, however, would have involved redesigning the whole hydraulic system, and the project was never executed. Thus, the improvements consisted of the introduction of new milling gear, which replaced what the committee deemed to be the watermill's very deficient system. The documentation generated by this project reveals that the new equipment, brought from Majorca along with a miller, were vertical wheels, which were to replace the existing penstock and horizontal wheels.[54]

We have an uninterrupted record of mill owners from 1797 onward. The mill continued to change hands frequently. It last did so in 1912, when it was exchanged for a rural estate. The mill ground its last grains of wheat about 1960.

Hydraulic systems in the Santa Eulàlia River and the torrent of Es Ierns

The hydraulic systems under study are built on the banks of the river of Santa Eulàlia River and the torrent of Ierns, which flows into the river just above its mouth. To the left of the river, there are two dams built to divert water to two channels that allow irrigation of an area of 12.18th ha (see Map 2). The first of these channels was used to supply the watermills. On the right bank, another channel irrigated 3.26 ha and then flowed into a small watermill, Es Molinet. The builders of the watermill took advantage of a sharp drop in a rock surface, which was also cut to adapt to the construction of the building.

Map 2.

The related channels must be, at least, coeval with the watermills, and we have seen that mills are well documented in 1235, then belonging to Andalusi times. The total area amenable to irrigation on both river banks is 14.93 ha, but not all of this area was under cultivation during the Muslim period. The sectors closest to the river, and thus those more vulnerable to flooding, were occupied more recently. In this regard, the report issued by the royal Improvement Committee mentions the presence of meadows and wetlands on the river banks, and claims that these areas could be improved and cultivated.[55] Thus, the plots irrigated by the second derivation on the left (2.4 ha) and some of the plots irrigated by the upper course of the channel on the right (2.24 ha), which are located in the floodplain, were very probably created after this report. The new additions, therefore, increased the overall size of the system by 4.64 ha. In conclusion, the area irrigated by the original system (first dam) on the left bank

[54] Arxiu Històric d'Eivissa i Formentera, *Expediente de ejecución del Plan político y económico aprobado por SM*, vol. I, fol. 174^{r}-75^{r}: in 1790, 'found that the watermills were so only in name, as they were built without the least ingenuity, as shown by the fact that they milled no more than three or four *quarteras* in twenty-four hours, the flour also being of poor quality'; 'the wheel and other parts for the new mill have been brought'; 'has found the most convenient place to install the new engine in one of Santa Eulalia's old mills'.

[55] Arxiu Històric d'Eivissa i Formentera, *Expediente de ejecución*, vol. I, fol. 324^{v}–25^{v}, 329^{r}.

was, at most, 9.78 ha. This system was spatially connected with a settlement area in Puig de Missa, where Andalusi pottery has been found. (see Map 3).[56]

Map 3.

On the right bank of the torrent, the original irrigated area must have included only the small plots on the rocky plateau located at the tail-end of the channel (0.51 ha). For most of its course, the channel skirted the floodable areas. This small agricultural area was linked to a settlement situated on the hill next to the river bank, where the farm of Can Toni de sa Torre is currently located (see Map 3).

As previously noted, the spring of Es Ierns is associated with a torrent that flows into the Santa Eulàlia River. The spring is now dry, but the width of the torrent seems to indicate that, in the past, the water flow must have been significant. The water was contained by a small dam from which two channels branch out. One runs along the left side of the torrent, while the other, after passing above the water course on a small aqueduct, runs along the right bank (see Map 2).

These structures were built in the 18th century. On 13th August 1737, Jaume Llaneres, a magistrate on Ibiza, reported that the spring was in a very poor state. Apparently, flooding was damaging the spring, the watermills were not working and the vegetable gardens lay abandoned. He recommended some works to remedy this situation: the construction of a stone and rubble wall a few meters above the spring to protect it and an 'arch' or bridge to channel the water towards the watermills. At that time, thirteen people owned vegetable gardens in this area. Llaneres's proposal was accepted on 20th August.[57]

Currently, the torrent is channelled from a point located above the spring. A footbridge provides access to the path that leads to the spring, and an aqueduct carries the water over to the right bank of the torrent and into the channel that supplied the watermills. The watermills themselves are no longer there, but are visible in aerial photographs taken in the 1970s.

Today, the hydraulic system is no longer in operation because the spring has dried up. Formerly, the channel that runs along the right bank diverted water to an area that was 6.28 ha in size. The channel runs more or less parallel to the torrent, and the intermediate area is occupied by a series of agricultural terraces. The area irrigated by the channel was divided into six blocks of agricultural plots, which were traversed by paths that run perpendicularly to the torrent and the channel. Above the channel, and therefore outside the irrigation system, there is a series of dryland agricultural terraces whose location corresponds to those in the interior of the irrigation perimeter. Similarly, the paths that traverse the irrigation system continue into the dryland area and provide access to the nearby farms.

The distribution of agricultural plots revolves around the network of paths and the sluice gates, the only exception being a series of long plots located towards the bottom of the valley, to which the terraced plots seem to adapt. This distribution suggests that these long plots are older than the terraces. Indeed, their elongated shape and the fact that the first one has a

[56] The evidence consists of some accidental finds and a small excavation carried out in 2012 under the direction of Glenda Graziani. This resulted in the excavation of fill with pottery, which was dated to the 12th and 13th centuries. We are grateful to Graziani for this information.

[57] Arxiu Històric d'Eivissa i Formentera, *Regidoria 1736–37*, fol. 228^{r}–29^{v}.

markedly narrow end seem to suggest that these plots were formerly supplied by a dam, no longer extant, which diverted water from the torrent. Also, the watermills and these long, valley-bottom plots were located along the same contour line, which suggests that they were all supplied by the same, now lost, dam and channel. In addition, below the first watermill, the valley-bottom plots have two terraces instead of three, as was the case above the watermill. This indicates that, after running through the watermill and dropping down the penstock, the channel resumed its course at a lower level. The valley-bottom plots are 2 ha in size and are associated with an Andalusi settlement located on an elevation on the right side of the torrent (Ca n'Armat) (see Map 3).

Concerning the hydraulic system on the left bank of the torrent of Es Ierns, as many as three construction phases can be attested (see Map 2). The earliest phase is represented by a fossilised block of agricultural plots that mirror those on the right bank. The elongated plots cover an area of 2.1 ha, and were supplied by a now lost channel that was symmetrical to that on the other side of the torrent. Both were served by the same derivation dam. This agricultural area was associated with two Andalusi settlements located on a small hill that dominates the valley (Can Ramon) (see Map 3).

The second phase corresponds to the 18th-century reforms. The most significant addition was a new channel that irrigated several blocks of terraces (4.4 ha), which were in their turn articulated around a network of footpaths. This new channel was built on higher ground than the earlier one. Finally, the current course of the channel was set out in the third construction phase. In this phase, the 18th-century channel was made to take a new turn near the hill of Can Ramon. As a result, the water flow was reversed, and instead of running towards the valley of Es Ierns, it flowed towards the right bank of the Santa Eulàlia River. Near the bend, a secondary channel branches out from the main channel. Unlike the other derivations, this secondary channel does not run perpendicular to the main channel and torrent, but parallel. The explanation lies in the fact that this, now secondary, channel reproduces the course of the 18th-century channel, and thereby runs symmetrical to its counterpart on the right bank of the torrent. The channels on both sides of the torrent of Ierns supply thirteen agricultural blocks, the same number of vegetable gardens mentioned in the 1737 report.

At the point where the flow changes direction to head towards the Santa Eulàlia River there are a number of water tanks. The construction technique indicates that these structures are recent and built on the cultivated surface. From this point onwards, the agricultural plots have a very different morphology from those located near the banks of Es Ierns. This recent addition is 8.2 ha in size.

In conclusion, in 1737 there were two symmetrical channels on the banks of the torrent of Es Ierns that included the Andalusi irrigation system in their perimeter. Although this earlier system does not feature in the written record and is, therefore, impossible to date with precision, its association with Andalusi settlement sites located on both sides of the torrent allow an Andalusi date for its construction to be proposed. The preserved channels correspond to the reforms implemented in 1737. The dryland and irrigation agricultural plots and roads were designed coherently, and access to the farms benefiting from this new layout was thus guaranteed. Today, this plot distribution is fully consolidated and reflects the 18th-century process of expansion and improvement of agricultural areas.[58] The latest expansion,

[58] See the analysis of traditional rural architecture in: Ferrer, *Arquitectura tradicional eivissenca*.

which is related to the diversion of the channel situated on the left bank, took place at an uncertain date. The use of cement in the construction of the cisterns and the diversion of the channel outside the torrent valley suggest that it should be dated from the 20 century.[59]

The archaeological survey of the Molí de Dalt

Molí de Dalt is located 849 m from the source of the Canal des Molins, which has a total length of 1,440 m. The watermill is situated at the point where the channel converges with a torrent that runs down from the nearby hills. Due to the presence of the torrent, there is a sharp drop in ground level (3.4 m), which was used to install the watermill. The water entered the watermill through the penstock and left it through the tail-race to re-join the main channel.

Map 4.

Figure 1.

The structural analysis of the extant features and the excavation of the interior revealed several phases in the construction sequence (see Map 4 and Figure 1). During the earliest of these phases, the course of the main channel ran approximately 5.5 m to the south of its current location, and was 0.95 m lower. This is clearly demonstrated by the discovery of a section of this channel embedded in the watermill's western wall (see Figure 2). No structural remains from the watermill associated with this phase of the channel have been found, so it must have been completely obliterated by later constructions. However, we can be certain that the penstock was not particularly high (2.2 m). The construction technique used in the early phase of the channel, which is visible in the southern façade of the watermill, includes rows of *opus spicatum*. On Ibiza, this technique is found in buildings dating from the 16th century and earlier, and also structures dating from the Andalusi period.[60] This wall sits on bedrock, so the excavation of its southern and western sides yielded no results. The height of the penstock suggests a small watermill, similar to those documented by S. Selma in Font de Quart, Valencia.[61]

Figure 2.

The second phase involved a profound transformation of the watermill and a section of the channel which supplied it. The new structures allowed an extra metre for the penstock without changing the location of the watermill. This transformation necessarily involved changing a section of the channel situated above the watermill. This section was moved north, and care was taken to lose as little gradient as possible. Elevation readings taken at the channel show that 250 m above the watermill the inclination is close to zero.

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[59] For the analysis of the hydraulic systems of Santa Eulàlia and Es Ierns, see: Kirchner, 'Migración y colonización agraria'.

[60] Ferrer, *Arquitectura tradicional eivissenca*.

[61] Selma Castell, *Els molins d'aigua medievals*, p. 62.

The most significant novelty in this phase was the diameter and height of the new penstock (2.05 m wide and 3.14 m tall) (see Figure 3). Once more, parallels may be found in S. Selma's works on Valencian watermills (e.g. Vall de Segó, which are equipped with large penstocks: 1.70 m and 2.30 m tall). These are, in fact, 'common where there is a large water flow'.[62]

Figure 3.

The third phase involved a great transformation of the watermill. The vertical penstock, horizontal wheel and vertical shaft were replaced by a vertical wheel. The penstock was completely demolished, the northern and eastern walls were pulled down, and the resulting rubble used as fill. The northern wall of the watermill was also demolished, along with the section of the evacuation chute that was next to the penstock. A chamber was built to host the vertical wheel, and the eastern and western walls were extended. The channel was diverted towards the new chamber, and the section that previously directed the water into the penstock was filled. The space available in the milling area doubled. In conclusion, this work resulted in the construction of a brand-new watermill on the location of the old one.

In the fourth construction phase, the previous vertical wheel, which was probably made of iron and wood, was replaced by one made completely of metal. This innovation allowed for the installation of two sets of millstones, plus a smaller one that was connected to the main shaft by a conveyor belt. The installation of the shaft and the gears that transmitted the motion to the millstones involved the lowering of the milling room surface.

The excavation and structural analysis of the watermill shed little light on the chronology of each of these construction phases, with the exception of the substitution of the old wheel for a metal one, which can be dated to the 19th century. The analysis of the written record and the reconstruction of the hydraulic system, however, can come to our aid in this regard.

As previously noted, the *Memoriale Divisionis* strongly indicates that the watermills already existed in 1235 and were, therefore, originally built during the Muslim period. On the other hand, the archaeological examination of the valley of Santa Eulàlia has defined the limits of the initial agricultural nucleus and of later expansions of the irrigation areas. The Canal des Molins and the associated Molí de Dalt correspond to the first construction phase, which is related to the settlement areas located on both sides of the river. To date, the archaeological and documentary records have failed to provide clear evidence for dating the earliest construction episode in Santa Eulàlia and Es Ierns. However, previous work on the Balearic Islands suggests that the process of agricultural colonisation was homogenous and, to a large extent, carried out by migrating groups, mostly Berbers from Al-Andalus, throughout the 10 century.[63]

The earliest mention of the Molí de Dalt watermill in the written record dates from 1266. The record makes it possible to trace the watermill's legal status between that date and its abandonment in 1964. Archaeology has revealed the presence of an early watermill which was also smaller than those that followed. The construction technique – opus spicatum – can be dated, by association with other examples found on the island, to the 16 century at the latest, and examples dating from the 15th century and even the Andalusi period also exist. It

[62] Selma Castell, 'De la construcció islàmica'.

[63] Barceló, 'Immigration berbère'.

may be claimed that these remains correspond to the Andalusi watermill mentioned in thirteenth- and 14-century documents.

A document dated from 1422 refers to major repairs carried out on the watermill after the structure had been abandoned for fifty years. The intention behind the document, which was to apply for a remission of the watermill's rents, must be borne in mind. It is possible that the issuer of the document may have exaggerated the scale of the works undertaken in order to support his application. It is, however, plausible that the transformations undergone by the structure at this stage included the installation of the large penstock and the redrawing of the course of the main channel. Although the archaeological evidence collected in the excavation neither confirms nor rejects this interpretation, it is supported by parallels found in the Valencia region.

The record is more revealing with regard to the third phase. The works recorded by the Improvement Committee fit well with the archaeological finds; a vertical 'wheel', brought from Majorca along with an 'expert miller', was introduced. This innovation was also implemented in all of the local watermills, except for the lower one, the Molí de Baix, 'because of its location in the lower part of the channel'.[64]

Discussion and conclusion

As hydraulic archaeology has amply demonstrated, the analysis of watermills cannot be carried out in isolation from the hydraulic system of which they are a part. In Santa Eulàlia, the opportunity arose to study one of these watermills in detail via structural analysis and excavation, which is the natural continuation of the previous examination of the system as a whole.

Once more, it was revealed that hydraulic elements are significantly resilient to change. As one of us pointed out elsewhere, 'continuity of use has involved a constant process of renovation of all technical devices: channels, retaining walls, basins and watermills. It is thus possible that the system layout may be in itself older than its component devices'. At any rate, we have noted how their location and key technical feature, the penstock, cannot be replaced without affecting the whole system.[65] This is what M. Barceló was referring to when he suggested the notion of rigidity, which has also to do with T. Glick's notion of the ultra-stable nature of hydraulic systems.[66]

In the case of the Molí de Dalt, in Santa Eulàlia, the constant renovation of the individual components of a fundamentally stable system can be seen very clearly. Up to four construction phases have been identified, but these were undertaken without the watermill changing location. In some cases, these phases involved a total renovation of the structure, so much so that the structural characteristics of the original watermill were almost completely obliterated. Its location was determined by a sharp drop in ground level, which was caused by a torrent flowing across the course of the main channel. All we can infer is that the watermill must have been small, and that its penstock cannot have been particularly high.

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[64] Arxiu Històric d'Eivissa i Formentera, *Expediente de ejecución*, vol. I, fol. 298^{r}: 'habiéndose suspendido la renovación del último molino por estar situado en la parte más baja de la azequia' (1791).

[65] Kirchner, 'Watermills in the Balearic Islands', pp. 45–55.

[66] Glick, 'El sentido arqueológico de las instituciones hidráulicas'; Barceló, 'El diseño de espacios irrigados'.

Also, it seems that, with each modification, the milling capacity of the watermill increased.

Therefore, the watermill cannot be understood in isolation from the hydraulic system, and the textual analysis also has to extend to the whole valley and its hydraulic systems. Watermills feature particularly often in the documentation of all periods. Unfortunately, each watermill is referred to using various names, as they are frequently identified by the name of their owner, the miller in charge, the characteristics of their machinery or their relative position within the system. Therefore, matching the watermills mentioned in the sources with the archaeological remains found during a survey is not always an easy task, and an impossible one if not all of the watermills and the hydraulic system are taken into consideration simultaneously.

The documentation also confirms another conclusion drawn by hydraulic archaeology: the introduction of the feudal rent-system had an enormous transformative – we could even say subversive – effect on Andalusi hydraulic systems equipped with watermills.[67] The 'unjustified fascination with technical factors' which was denounced by M. Barceló, has pushed 'the true builders of the hydraulic systems out of the limelight'.[68] Interest in watermills frequently stops at the building and machinery. It is true that the written record encourages this limited perspective, because it treats watermills as though they were isolated devices, quite detached from the technical complexities of the channels without which they could not operate and irrespective of the organisation of water-sharing institutions. Furthermore, the main focus of the documentation rests on their associated rents and dues.

The Molí de Dalt, or, better still, the sequence of watermills built on its location, has a long history: it was in use for approximately a millennium. This longevity notwithstanding, none of its managers changed its mechanical properties until the state intervened in the 18th century; the penstock was in place for eight hundred years. The introduction of the vertical wheel was prompted by the Improvement Committee, which also wanted, at a time when prioritising milling over irrigation already had a long tradition, to move the watermills towards the higher course of the channel in order to increase the water supply. The stability of the system created in the 10th century made this project unviable, and the watermills remained where they had always been.

On the other hand, the small size of the irrigation blocks identified at the lower end of the valley of Es Ierns fits with other Andalusi examples from the Balearic Islands, the average size of which is around 1 ha.[69] Conversely, the irrigated space located in the valley of the Santa Eulàlia River (10.29 ha) is well above this average. On the Balearic Islands, only hydraulic systems that enjoyed a plentiful water supply were equipped with watermills, as these can only operate if the water supply is both abundant and regular. It is, therefore, not so surprising that watermills only appear in relation to the largest of the hydraulic systems built in the Andalusi period.[70]

Before the 18th century, when the reforms introduced by Enlightened agronomists shifted agricultural practices towards specialisation and the growing of market crops, little was done to expand the irrigation areas. Within the limits set by the water flow, however, significant

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[67] Kirchner, 'Conquista y colonización'; Kirchner, 'Colonització de *lo regne*'.

[68] Barceló, 'Pròleg', p. 13.

[69] Sitjes, 'Inventario de sistemas hidráulicos'.

[70] Kirchner, 'Watermills in the Balearic Islands'.

expansions took place at this time. On the lower course of the Santa Eulàlia River the irrigated area was enlarged by 4.64 ha. Around the torrent of Es Ierns, 10.68 ha were added in the 18th century and an additional 8.2 ha in the 20.[71] Around the watermill, these changes tended to respect the original Andalusi layout and perimeter, which thus became a limiting factor. In Santa Eulàlia, the expansion encroached upon flood areas and in Es Ierns the spring water was collected by means of a dam reservoir in order to feed two channels that were located higher than the original channels.

In conclusion, we may say that the rigid relationship between the different elements that constituted the hydraulic system is the reason behind the stable position of the watermills over time. Despite later expansions and reforms, the original design of the hydraulic system was to have a long-lasting effect upon the characteristics of the surrounding agricultural landscape.

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