Hydraulic technology as means of Christian colonisation. Watermills and channels in the Lower Ebro (Catalonia).

World Archaeology

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Abstract
In this study, evidence provided by written records generated after the conquest of Tortosa in 1148 and the results of archaeological survey have led to the identification of several farmland areas and their associated Andalusi settlements on both banks of the River Ebro, in the hinterland of Madīna Ṭurṭūsha. These field systems were formed by compact and discontinuous cultivation areas on the riverbanks. Drainage channels and wells with water-lifting wheels comprised the main hydraulic techniques used. One of the most relevant changes as a consequence of feudal conquest was the introduction of new hydraulic systems consisting of water catchment in the hills above the river and long channels, whose main purpose was to drive watermills. These channels were rather complex in terms of technology and distinct from those of the Muslim peasant tradition and we can recognise the political power behind them.

Keywords
Landscape archaeology, field systems, hydraulic technology, watermill, al-Andalus, Christian conquest, colonisation.

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Introduction

The city of Madīna Ṭurṭūsha (Tortosa) was located in the administrative district of the so-called Upper March of al-Andalus[1] (*al-Thaghr al-Aʿlà*), which was roughly circumscribed to the Ebro Valley (Garcia Biosca et al. 1998; Kirchner and Virgili 2015). It surrendered to the army led by the Count of Barcelona, Ramon Berenguer IV, in December 1148. The conquest was followed by a process of colonisation that generated hundreds of documents, containing relevant information concerning the agricultural landscape found by the conquerors and the changes introduced by the colonists in the following decades (Virgili 2001)[2]. These changes consisted of the enlargement of agricultural areas on the riverbanks and the creation of new hydraulic systems, the main function of which was to supply water to newly built watermills (Virgili 2018, 2020; Kirchner and Virgili 2018; Virgili and Kirchner 2019).

Josep Torró has referred to changes occurring after the feudal conquests as a process of 'agrarisation', a notion broader than R. Barlett's 'cerealisation' to characterise the creation of new agricultural areas for growing cereal (Bartlett 1993). Torró contends that the process was more complex, both in terms of the extensive crops introduced at this time (cereal, vines and olive trees), and the alternative colonisation strategies, like herding in sparsely populated areas. Similarly, the technical solutions adopted and their impact upon the landscape were diverse, and include the breaking-up of uncultivated grazing areas and the modification or expansion of Andalusi field systems. In addition, the settlement pattern changed radically, including the wholesale abandonment of Andalusi settlements, the deportation of Muslim communities, the reoccupation of some settlements by Christian colonists, the foundation of new settlements and towns, and the construction of new urban districts in the existing cities (Torró 2019).

Such colonisation processes are attested in New Catalonia,[3] Valencia, Aragón and the Balearic Islands, although the scale of operations and the technical solutions adopted varied from case to case.[4] The practices attested include the creation of new irrigation systems, the expansion of ancient ones, the introduction of new watermills, the construction of terrace systems for dry-land agriculture and the breaking-up of drained wetlands. These operations involved the allocation of land plots to newly arrived colonists, which were legally framed as rent-generating emphyteutic land leases (Kirchner 2018, Torró 2019).

In New Catalonia, the channels of Pinyana and Torres, in Lérida, also postdate the conquest of the city, although Andalusi irrigation systems already existed there (Eritja 1998; Marfull 2014, 2017). C. Batet has attested that both the secular lords and the Cistercian monasteries were interested in taking control over existing peasant systems in conquered areas, including the irrigation systems, channels and mills. In the event, they built new watermills, but not new irrigation systems (Batet 2006).

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[1] The term Andalusi is the demonym of al-Andalus.

[2] Most of these documents are already available in published form. They will be cited by the acronyms of the documentary collections (see Bibliography).

[3] New Catalonia includes the Southern and Western part of Catalonia, conquered by the Catalan counts in the 11th and 12th century. Old Catalonia is the name given to the Northeastern part of Catalonia, which fell under the authority of the Carolingian counts in the 9th century and which, therefore, was only slightly integrated in the Andalusi political order.

[4] Some research cases on several regions of the Iberian peninsula have been published recently (Torró y Guinot eds. 2018)

In Valencia, the Andalusi hydraulic system associated with the *madīna* was based on small and discontinuous field systems, most of them related to different rural settlements, although all were supplied by a single, major canal. The expansion of this hydraulic system in the wake of the conquest involved the irrigation of land that had previously remained uncultivated or non-irrigated in the interstices between the Andalusi channel networks (Guinot, Esquilache 2010: 127-148; Guinot 2018; Esquilache 2018).[5] Furthermore, several hydraulic systems were built anew. The Crown was the main developer behind these constructions, for instance in the channels of Alzira (1258-72) (Peris Albentosa 1992, Torró 2019) and Vila-real, a newly founded city (1272-74) (Guinot, Selma 2012, Torró 2019). In the rural areas of the kingdom, lords and local councils promoted smaller projects (Torró 2005, 2010).

The expansion of cultivated areas and the construction of new irrigation systems and watermills, some in existing channels, also took place in Aragón (Laliena 1994, 2008; Ortega 2010; Laliena and Ortega 2012). In Mallorca, new watermills were constructed in former Andalusi irrigation systems, and new water management criteria which prioritised grain milling over irrigation were introduced, while vines took an increasing proportion of irrigated land (Kirchner 1995, 2018, Batet 2006).

In Valencia and Mallorca, the creation of regular field systems is associated to land distribution processes and the settlement of colonists between the mid-13th and early 14th centuries (González Villaescusa 2002: 450-452, 467-468; Torró 1998, Guinot 2018; Kirchner 2003, 2018; Mas 2018).

The draining of wetlands was especially active in Valencia, in close connection with irrigation systems (Torró 2009, 2010, 2016; Torró, Esquilache 2018). A similar draining project was undertaken in the coastal wetland of Pla de Vila, below the city of Ibiza, although in this case the draining operation had already begun before the Catalonian conquest (Barceló *et al.* 1997).

Hydraulic works were not only built in conquered areas, but also in the regions where the conquerors came from, and with a similar chronology (Caucanas 1995, Kirchner et al. 2002). But it was not until the late 12th and early 13th century that the crown and urban councils began promoting the construction of hydraulic infrastructures.[6] In this regard, the hydraulic works carried out in the conquered areas of Valencia, Aragon and New Catalonia (Lleida and Tortosa) had contemporary or earlier parallels in Old Catalonia, and all these systems seem to have responded to similar criteria. In all cases, the ultimate objective of these programs was to raise rents for the crown (Kirchner 2018).

The Andalusi agrarian landscape before the Catalan conquest in the Baix Ebre (Lower Ebro).

The abundant information provided by the texts, along with the results of archaeological survey have allowed us to map the settlements and their associated agricultural areas on both sides of the Ebro River (Kirchner and Virgili 2016). The inhabited areas are referred to as *villa* or *locus* and the mention of houses, mosques and cemeteries suggests that these were concentrated settlements, even if small in size. They are recognisable through pottery surface scatters, silos and sometimes the remains of walls. They were generally located on the edge of the fluvial plain, in small knolls or above the river terraces. All of them are spatially related to the Andalusi agricultural areas. Both the

[5] *Huerta* is an irrigated area located around a city.

[6] Also in Italy, written sources suggest a significant increase in hydraulic projects from the 12th century on. Italian communes and monastic institutions were usually the promoters of these projects (Magnusson, Squatriti 2000). A similar process is noticed at the same time in France cities (Benoît, Rouillard 2000).

residential and agricultural areas are located above inundation levels. The settlements were connected by two main roads running parallel to the riverbanks and barges were used to cross the river in Tortosa, Benifallet, Xerta and Amposta. Finally, near the river mouth, the settlements formed a row along the shores of the delta, on high ground and rocky promontories surrounded by marshland and lagoons. (Fig.1). The place-names, often still preserved, allude to landscape features or to the identity of the settlers (Barceló coord. 1999).

FIGURE 1: The Baix Ebre: settlements and agricultural areas.

The references to the river in the written record indicate that the riverbed was much wider and less neatly defined than it is today. Andalusi field clusters tended to occupy slightly elevated areas on the riverbank, near the mouth of the torrents that run down the mountain ranges flanking the fluvial plain. These torrents swept along sediment and formed fan-shaped formations that are still recognizable because of their well-defined limits and because they are slightly elevated vis-à-vis the surrounding fluvial plain. Broad uncultivated tracts of land and marshlands were left between the compact agricultural land clusters. The written record mentions wells, water-lifting wheels (*sāniya*) and water reservoirs which allowed for the plots to be irrigated regularly.[7]
The *algeziras* or *insulae* ('islands', from the Arabic *al-jazīra*) refer to spaces that were partially surrounded by branches of the river. The written record suggests that they were mainly used as grazing areas and for the gathering of wild resources, but also as agricultural areas, as there are several mentions of trees and cultivated fields from a very early date (Virgili and Kirchner 2019).
Madīna Ṭurṭūsha was directly connected with two agricultural areas: the *huerta* of Pimpí and Les Arenes (Kirchner et al. 2014; Kirchner and Virgili 2019). The *huerta* of Pimpí (*orta de Pimpino*, in the record) was located to the north of the *madīna*, alongside the road that ran parallel to the river (18 ha). According to the written record, half of the plots were used as vegetable gardens. Irrigation was achieved by means of wells with water-lifting wheels. The strip of land that is closest to the current riverbank was broken up for cultivation in the modern era (Fig. 2).

FIGURE 2: The irrigated area of Pimpí near Madīna Ṭurṭūsha

Les Arenes is a large alluvial plain to the south of the city, outlined by a wide meander. Following the written record, the agricultural plots were presumably sown with cereal. The nine channels (*cequia*) mentioned were part of a drainage system aimed at regulating and evacuating excess water caused by the rise of the river and by sudden run-offs coming from the torrents. The frequent mention of *cequias* in the earliest Christian documents seems to indicate that the network was already in place, at least partially, at the time of the conquest. In order to obtain initial dates and additional

[7] The bibliography on hydraulic techniques conventionally uses the Arabic term *sāqiya* to designate this water-lifting device, which is characterised by a gear connected to a chain of pots that sink into the well and come back to the surface full of water; the gear is propelled by an animal tied to a vertical shaft. The Catalan term *sénia* derives from *sāniya*, while the term *sāqiya* has instead evolved into *séquia* (Catalan), *cequia* (in Latin documents) and *acequia* (Spanish), meaning channel. For a classic reference see Schiøler 1973.

information about the drainage system, the geoarcheological analysis of a sediment column was carried out. The results of these analyses have linked drier environmental conditions, between AD 686 and 873/720 and 944, with the earliest drainage of Les Arenes, which is likely dated to the 8th century (Puy et al. 2014). The field survey carried out in Les Arenes shows that the drainage channels were constructed in successive stages, following a north-to-south and east-to-west general direction (Fig. 3).

FIGURE 3: The drained area of Arenes, south of Madīna Ṭurṭūsha.

South of Les Arenes there was an extensive area which in the written record is referred to as a 'meadow'(*pratum* of Tortosa) within the river inundation area. In this sector, the properties are referred to as "plots of land" or "fields"; barely two vineyards and one vegetable garden are mentioned in the record. Some towers, as they stand today, are not dated to the Andalusi period, but to the second half of the12th century or slightly later (Mateu, in press). The meadow of Tortosa was rich in pastureland and was traversed by a network of droveways (Virgili 2019, 2020).
Finally, the only mills attested during the Andalusi period are those described by the geographer al-Qazwīnī, who claims that mills built on river barges existed in Tortosa.[8]

The *insula* and the watermills of Xerta

Xerta was an Andalusi settlement associated with one of these land clusters irrigated by means of water-lifting wheels (Virgili and Kirchner 2019). There are mentions of several wells and water-lifting wheels: in 1160, an estate is mentioned *cum arboribus, cum puteis, cum vineis* (DCT: 112); and in 1174, another estate included houses, cultivated and uncultivated lands, vegetable gardens, vines, trees including olive trees *cum puteis, ceniis et molendinis* (DSC: 178). The Andalusi field system probably corresponds to the areas equipped with water-lifting wheels, situated immediately below the two settlements detected during archaeological survey (Fig. 4 zones D and C).

FIGURE 4: Xerta's agricultural area: the Andalusí plots and the algezira

The first attempts to colonise the *algezira* (island) of Xerta, by the Bishop of Tortosa, date to the 13th century. Between 1205 and 1214, the bishop of Tortosa and the prior of the cathedral chapter offered a series of grants to new settlers with the condition of working the land, breaking up the uncultivated areas (*expletes et labores … et quod plantes terra inculta*) and paying an annual rent (DCT: 649, 652, 653, 698, 777). The plots were located in the fluvial island and in some cases bordered the Ebro and the so-called *alalix*. The word *alalix* (also written as *alalegio, alfalig* and *alfalegio*), come from the Arabic *al-ḥalij*, which means 'gulf', a largely stagnant backwater (Bramon 2012, 17). The *alalix* of Xerta always borders with the *algezira* (DCT: 649, 652). This term could refer to a branch of the river that separated the *algezira* from the shore and later turned into a channel. These channels are currently known as 'galatxos'.

[8] "There are also mills built on barges, so the wheel turns outside the barge with the current, and the miller can move the mill around if he so wishes. Similar mills exist in the Tigris River, in Mossul, and they are known as *al-ġ.rba*" (Bramon 2000:125).

The *alalix* and the *algezira* must be located in the major meander that the Ebro traces near Xerta, where some place names refer to both the island and the *alalix* (Mas del Galatxo - Galatxo's farm, Camí de les Illes - Islands pathway, Les Illes – The Islands) (Fig.4, area B). This is the area where the colonisation process led by the episcopal see took place. The rest of the meander was probably part of the river bed (Fig. 4, area E). Mentions of the *cequia* and of the watermills of Xerta date to the late 12th or early 13th century. In an inventory of the property owned by the monastery of Poblet, in Xerta, which could be dated to approximately 1200 (CP: 215), mention is made of a public *cequia*. This could be the first mention of the *cequia* constructed to supply the watermills. Four further mentions of *cequias*, in 1182 and 1200, are probably drainage channels dug after the conquest (DCT: 348; CTT: 119; CP: 215).
The current course of the mills' channel starts at the dam built in the ravine of Las Fonts.[9] The course of the *cequia* shifts further down, where it is channelled through a tunnel that cuts through a large rock (La Foradada) before reaching three watermills. After powering these watermills, the water is channelled to irrigate the plots of land that surround the village of Xerta (Fig. 5).

FIGURE 5. The watermill's cequia of Xerta overlapping the Andalusi agricultural area.

The hydraulic system is accurately described in the document known as *Privilegi de les aigües de Xerta*, granted by Peter IV, King of Aragon and Count of Barcelona, on 5th February 1383 (Añón 1910). This privilege brought an ongoing controversy to an end: the village leaders and the Council of Xerta had been denounced by the inhabitants of Paüls for taking over the running water around Paüls. The inhabitants of Xerta argued that they had used this water long before the conquest of Tortosa. The king acquitted the people of Xerta and granted them the use of the water. It is clear from the document that, in the late 14th century, the hydraulic system was believed to be Andalusi in origin. However, the outline of the system, the late mention of watermills and the similarities with the Count's mills, which were, as we will see, built after the conquest, suggest that the channel of Xerta is a post-conquest construction.

The Palomera area and the Count's mills

Palomera is mentioned in the records as a 'place' (*locus*) (CCT: 6, 8,10, 11, 13, 14, 15, 22, 97 DCT: 219, 268, 273, 301, 396, 517, 534, 602, 746) and designated an area in the mouth of the Cervera torrent. The eastern boundary of four plots of land faced the Ebro (CTT: 8). The northern and southern boundaries of some of the plots are said to have faced a public roadway that ran parallel to the torrent (CTT: 16; DCT: 118, 257, 534). The western and eastern boundaries are also associated to a pathway that ran parallel to the Ebro (CTT: 10; DCT: 268, 375, 396). So, the agricultural land spread from the margins of the Ebro to the Cervera valley. Also mentioned are an *alfalig* and an *algezira* (CTT: 97), which were probably located between the mouth of the torrent and the Ebro (ACA: codex 115, d. 273, f. 86r). Two vegetable gardens are mentioned, one of which had a well (*ortalem que fuit de sarraceno nomine Abnilupon … cum puteo et cum omnia arborea*. CTT: 6).

[9] Dams in torrents are very simple structures built with stones and tree branches that partially slow down the speed of water and allow for a small portion of the flow to be diverted into a channel. The Catalan term used to design this structures is *assut* (Spanish: *azud*) (from *al-sudd*, a dialectal form of the Arabic *al-sadd*).

Most of the plots of land documented are labelled as *terra* and *campus* (24 and 15 mentions respectively), although vines, olive trees and two vegetable gardens are also attested. Finally, the term *honor* is used to refer to ten plots of land, the use of which is uncertain.
In 1163, an *honor* that had belonged to Aliafar Aberramia and which Pere Guillem Aragonès had received from the count, was near the 'king's *almunia*' (*almunia de rex*) (DCT: 136). This probably is an allusion to Tortosa's Andalusi governor. Pere Guillem Aragonès and Guillem Rabassa shared another nearby *almunia*, planted with vines, fig trees and cereal. Finally, another *almunia* belonged to Sança Aragonès (DCT: 219, 268). These *almunias* were agricultural areas located in the vicinity of other plots of land, and there is no evidence of the existence of settlements on them[10](Fig. 6).

FIGURE 6: The Andalusi cultivated area of Palomera and the channel of Count's mills.

The construction of the watermills in Palomera postdate the conquest, as demonstrated by a series of documents that refer to their construction and to their owners, the Count and the Bishop. In 1164, King Alfons II granted Bishop Gaufred land to build a mill near the water that ran down the mountain slope in the direction of Tortosa (DCT: 141). Years later (1178), the Count-King in the grant charter given to the cathedral of Saint Mary in Tortosa confirms the donation of the mill, along with half of the mills owned by the king (DCT: 301). This is the origin of the complex still known nowadays as Molins del Comte (*molendina comitis*) (the Count's mills) in Palomera. A document locates the mills to the west of Palomera (CR: 165-166). Again, in a grant dated to 1194, King Alfons transferred half the mills, with their water rights (from the source in Mount Tresere to the Ebro) (DCT: 517). A clause in the donation indicates that only the bishop and the prior, or whomever they authorise, could build a mill over the whole course of the channel.

FIGURE 7: *The channel of the watermills in the Cervera torrent.*

These are three mills built on the left bank of the torrent and powered by the same channel which runs from one mill to the next (fig. 7). Catchment of the channel was in the upper course of the torrent of Cervera. The channel is 5021 m long, and flows into a large water reservoir. Water is channelled from this reservoir to the first mill's penstock, located above the fluvial terrace (Fig. 8, 9). The second mill is located between the fluvial terrace and the stream's valley, and the third is at the bottom of the valley. The penstock of all three mills and the space that hosted the wheel of the third are preserved. The level where the millstones were installed and the remaining structures are either lost or, in the case of the second mill, in a poor state of preservation.

FIGURE 8:Entrance to the vertical shaft of the first mill in the Cervera torrent

FIGURE 9: Remains of the vertical shaft of the first mill in the Cervera torrent

[10] The *al-munya* (Arabic) has been described as a private property, usually linked to members of the state administration or people related to it (Navarro, Trillo eds. 2018).

Before reaching the Count's mills, the channel flowed into another mill which has been identified as the Alcàsser mill mentioned in other documents. The penstock is well preserved, although the chute is now blocked, as is the channel right below and above the building. A masonry wall with an arrow-slit identified inside the building may suggest the presence of a tower. Alcàsser comes from the Arabic *al-qaṣr*, which can refer to a fortification.
In a document dated to 23rd March 1236, the bishop and the prior, on behalf of the cathedral chapter, leased a mill to Bernat Moliner in exchange for a rent in cash (ACT 953). The parchment is poorly preserved, and is difficult to read but the specifications for the mill are written on the reverse (*Stabilimentum molendini del Alcasser*). The mill had been built by the lessee and it seems that its construction predates the contract. Years later, on 1st September 1273, Bishop Arnau de Jardí, the prior Pere de Puig and the chapter, granted Maria of 'Zalcacer' and her sons Pere and Ferrer permission to build a penstock mill with stone and timber, but not a reservoir, because this could hamper the water flow towards the Count's mills (ACT, unpublished parchment, Calaix 59). The fact that Maria's surname is linked to Alcàsser suggests that this mill is the same one mentioned in the previous document, although in this earlier document the construction of the mill is attributed to Bernat Moliner. At any rate, the mill was built after the conquest and years after the construction of the Count's mills and of the channel that fed them (Fig. 10).

FIGURE 10: The channel of the Cervera torrent and the Alcàsser watermill

So the mills in the Cervera torrent were built after the conquest. The catchment area and the course of the channel are designed to bring water to the reservoir, and from the reservoir to the mills. There is no evidence for a previous Andalusi irrigation channel servicing the agricultural area of Palomera.

Opposite Tortosa, on the right riverbank: *ultra Iberis* and the Sant Antoni torrent

The area located on the right side of the Ebro and opposite Tortosa is referred to in the written record as '*ultra Iberis*' ('beyond the Ebro'). From this sector southwards, meadows and wetlands were the predominant feature. Several settlements (Vinallop, Beniguerau), fluvial islands - one of them with a toponym (*Algezira Mascor*) (TTE: 109; CTT: 126; DCT: 743) and a bridge (*alcantaram*; *al-qanṭara* in Arabic)[11] were located around the mouth of the Sant Antoni torrent and the road to Valencia. [12] There are also references to the meadow (*pratum*) and a reedbed (*cannar*) (ACA: Codex 115, d. 109, f. 34r).
The sediments deposited by the stream of Sant Antoni contributed to the formation of islands. Like in the mouths of other water courses, cultivation areas were situated slightly above the rest of the alluvial plain (Fig. 11). All the plots of land mentioned in the record are labelled as *terra* or *campus* (18 mentions each), which suggests that this

[11] A plot of land of Algezira Mascor was *prope ipsam alcantaram* (DCT:69); a field *iuxta viam quam itur ad Valenciam prope ponten siccum et prope algziram que fuit de Zahada* (DCT: 63); one plot of land of Beniguerau bordered to the south by a *cequia* and the Alcantera, and to the east with a road that led to Alcantera (TTE: 35).
[12] The Valencia road is mentioned in different documents as a limit for the plots of this area (CTT: 44, 45; DCT: 368; ACA: Codex 115, d. 109, f. 34r; CTT: 26, 74).

land was used primarily to sow cereal. No mention of vegetable gardens is made, although there is a reference to a well and a reservoir, which suggests that irrigation was undertaken by means of water-lifting wheels (DCT: 63). There are a few references to channels (*cequia*), which were probably for drainage.
However, the *cequia maior*, which is partially preserved, had its source at the top end of the stream of Sant Antoni (DCT: 212). This channel is mentioned in a document through which the prior of Tortosa cathedral granted the hospital of the bishopric the tithe payable by the properties of the "main channel" (*cequia illa maiori*). The document also describes the channel's itinerary: *cequia illa maiori inferius que descendit de Marenxa et venit per Algevira Mazcor ad Yberum* (DCT: 398). Several plots of land are documented in Marenxa, one of which was flanked by the *cequia* on one side and a public pathway on the other (CTT: 91). This channel is later mentioned in a 16th century document that establishes grazing rights (MTE *Llibre del Pastoret*, 100-102). The channel is mentioned in the description of a drover's path that runs from Marenxa to the "Sedó path" and joined the Valencia road. The name of Sedó is currently used to refer to an existing watermill.[13] Therefore, Marenxa was located somewhere between the point where the Sant Antoni torrent begins and the Sedó watermill. The channel that brought the water to the Sedó watermill is partially preserved today though it is not in use. The channel's source was in a dam built at the top-end of the stream of Sant Antoni, bringing the water to a reservoir from where it flowed into the mill.
The same channel could be used to irrigate a 2.4 ha area located immediately past the mill, near the riverbank. The remains of a water-lifting wheel, nevertheless, suggest that the original irrigation procedure was not the channel (Fig. 11). The channel was built with a specific purpose: feeding the mill with water. There is not a precise date for this but the layout of the channel is exactly the same as the one found in the Count's mills. Therefore, it is very likely that, like the Count's mills, the Sedó mill and the associated channel were built after the conquest.

FIGURE 11: Channel of the Sedó watermill and the plots at the mouth of the Sant Antoni torrent.

Mills in the meadow of Tortosa
South of Tortosa, on the left river bank, there was a large area of marshes, the *prato* (meadow), between the Arenes area and the mouth of the Ebro. A series of toponyms are associated to this extensive area of riverside wetland: Aquilen, Quint, Burjassènia, La Aldea, Antic, Granadella and Camarles. The record mentions *cequias*, for drainage, ponds and small clusters of agricultural plots of land (Kirchner and Virgili 2019; Virgili 2019, 2020). The Templars received land grants from the count and the purchased additional land. Clusters of plots irrigated by water-lifting wheels, which may be of Andalusi origin, have been attested in some of the settlements (Quint, Burjassénia, La

[13] J. Negre (2015, 28-31) is mistaken in his interpretation of this and other documents, and argues for the construction of a long channel, which drew water from the river Ebro, promoted by the Caliphate of Cordoba. These channels never sourced their water from the Ebro River. The characteristics of the riverbed made it very difficult to construct a dam to divert water into channels away from the river. The riverbed was much wider than it is today, and multiple branches shifted seasonally; the margins were fairly unstable and the slope gentle, hampering the construction of a dam capable of diverting the water far enough from the riverbank to be effective. This was tried for the first time in the 14th century, but the project did not come to fruition until the 19th century, when the course of the river had already been partially channelled (Fabregat and Vidal 2007; Vidal 2010; Rovira and Muñoz 2013).

Aldea). However, the breaking up of new land sponsored by the Templars focused on the area of wetland, and involved the construction of drainage channels (Virgili 2019, 2020).
In 1172, Oller de Tamarit granted Ramon de Montcada a field with a mill and the associated channels (*caput rego*), the water rights and the meadow in La Pedrera (ACA, OO. MM., Gran Priorat, Tortosa, codex 116, d. 155, f. 51r). The Montcada family transferred their rights over the mill to the Templars (CCT: doc. 63), and in mid-December 1176, Radulf Barbablanca, a Genoese who had participated in the conquest of Tortosa, sold the order all the rights over the mill that Montcada had awarded him (CCT: doc. 64). There is little doubt that this is the same mill, and it is mentioned again in 1185 as part of the Templars' property in the Quint's meadows (DCT: doc. 383; CCT: doc. 88) (Virgili 2020).
The mill of Soldevila, which is probably the one mentioned in the 12th-century record, stood in Quint until recently. It was supplied by a channel whose source was located in a nearby natural spring. The remains were demolished in 1989 during the construction of a pumping station to send water from the Ebro to Tarragona (Virgili 2020) (Fig. 3). A series of silos were found nearby (Arbeloa 1997).

Conclusions. The Feudal changes of the agricultural landscape

The changes introduced after the conquest of Tortosa mostly involved the breaking-up of areas like the river islands and waterlogged meadows on the riverbanks and the construction of new hydraulic systems for watermills. The expansion of cultivation areas took place largely in the meadow areas to the south of Tortosa, from the area of Las Arenas to the coast. In Xerta and Tivenys, the new settlers also broke up hitherto uncultivated land on the riverbanks, the so-called 'islands' (*algeziras*) (Virgili 2019, 2020; Virgili and Kirchner 2019). The crops introduced in these new agricultural fields were cereal, vines, olive trees, and fruit trees, the demand for which was growing, especially in cities. *Donationes ad censum*, were the legal instruments used to promote specific crops (Virgili 2018).
The process of expansion of agricultural land is coetaneous with the construction of watermills, right after the 1148 conquest, and their supply infrastructure consisted of water-catchment dams in torrents and long channelling systems for the conduction of the water to the watermills. The new hydraulic systems partially overlapped with Andalusi agricultural areas located at the mouth of the torrents. The design of the channels associated with the mills of Xerta, Palomera, Sedó and Soldevila follows a common pattern: the catchment point is in a mountain stream - or a spring in the Soldevila case -, and the water runs for a considerable distance to reach the mills. Except for the Soldevila mill, the mills are located right above the Andalusi plots of land.
The irrigation channels and mills were erected on the initiative of the count and the bishop (Palomera), the monastery of Santes Creus (Xerta) and an unidentified person in the stream of Sant Antoni and Quint. In Quint, the mill's management later fell to the Templars. Therefore, they were the agents responsible for the colonisation of the Baix Ebre, the count playing an especially prominent role. All of them were especially keen to control the mills.
Although Andalusi channels and mills have been attested elsewhere, evidence for them in the Lower Ebre is lacking. It does not appear that the Andalusi governor of Tortosa or any other public official promoted the construction of this sort of infrastructure. The *almunias* that feature in the record, some of which were associated with the governor –

e.g. one in Palomera and another one in Bítem, on the left riverbank north of Tortosa – were irrigated by means of wells and water-lifting wheels, and they were part of broader field systems. From a technical point of view, agricultural property which had some sort of connection with the Andalusi state – the *almunias* - was no different to the rest. They occupied the same sediment-formed areas in the river mouths as peasant-owned properties, and followed the same technical criteria: they used the natural relief to their advantage, they tended to occupy sedimentary soils left by torrents, which were less exposed to flooding, and they used wells and water-lifting wheels for irrigation (Kirchner in press).

The only mills documented for the Andalusi period are the mills built on barges mentioned by al-Qazwīnī. They remained in operation after the feudal conquest, but probably not for long, as they competed with the newly-built mills of Xerta, Palomera, Sant Antoni and Soldevila (Virgili et al. in press). Those installed on the boat bridge in the city of Tortosa and the windmills built on the hills that surround the city were owned by the city council, and are documented from the 14th century (Vidal 2008, 235-240). Until that time, the city lacked its own mills, but had to find technical alternatives since there was no possibility of building additional mills in the channels of Xerta and Palomera or the Sant Antoni stream.

The contrast between the technical choices made during the Andalusi and feudal periods is clear. During the Andalusi period, state-related agricultural areas adapted to peasant-led criteria. State officials built neither major channels nor mills; milling was undertaken in barge mills on the riverbank. During the feudal period, the intervention of the count and the beneficiaries of the conquest followed entirely new criteria. The construction of channels and watermills is one of the most visible expressions of this transformation. Other actions were the breaking up of new land in fluvial islands and in the meander south of Tortosa and the adoption of vines as the main crop. The extensive areas that lay between field systems were used for grazing, hunting and gathering. Conflicts between the Templars and the inhabitants of Tortosa demonstrate that common land exploitation regimes existed, which were probably an inheritance of the Andalusi period, in the meadow of Tortosa (*pratum*), the largest wetland in the region. The Templars were interested not only in controlling this pasture area, but also of keeping the inhabitants of Tortosa away from it (Virgili 2020).

Each of these actions contributed to transform the landscape, but they cannot be understood only in physical terms (new land boundaries, construction of channels and watermills) or only in terms of the survival of Andalusi agricultural regimes (discontinuous field systems located in areas characterised by the abundance of sedimentary soils, water-lifting wheels, etc.). The transformation of the landscape was consubstantial with the process of colonisation that followed the conquest, and therefore with the imposition of rent-seeking regimes upon the peasants that became the instrument of this colonisation.

Figure captions

FIGURE 1: The Baix Ebre: settlements and agricultural areas.
FIGURE 2: The irrigated area of Pimpí near Madīna Ṭurṭūsha
FIGURE 3: The drained area of Arenes, south Madīna Ṭurṭūsha.
FIGURE 4: Xerta's agricultural area: the Andalusí plots and the *algezira*
FIGURE 5. The watermill's *cequia* of Xerta overlapping the Andalusi agricultural area.
FIGURE 6: The Andalusi cultivated area of Palomera and the channel of Count's mills.
FIGURE 7: The channel of the watermills in the Cervera torrent.
FIGURE 8: Entrance of the vertical shaft of the first mill of Cervera torrent
FIGURE 9: Remains of the vertical shaft of the first mill in the Cervera torrent
FIGURE 10: The channel of the Cervera torrent and the Alcàsser watermill
FIGURE 11: Channel of the Sedó watermill and the plots at the mouth of the Sant Antoni torrent.

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