Ireland's fallow deer: their historical, archaeological and biomolecular records

Fiona Beglane[ab], Karis Baker[c], Ruth F. Carden[d], A. Rus Hoelzel[c], Angel Lamb[e], Rita Mhig Fhionnghaile[a], Holly Miller[f], Naomi Sykes[f*]

[a] Centre for Environmental Research Innovation and Sustainability, School of Science, Institute of Technology, Sligo, Ash Lane, Sligo, Ireland. beglane.fiona@itsligo.ie

[b] Consultant Zooarchaeologist

[c] Department of Biosciences, Durham University, South Road, Durham DH1 3LE, UK.

[d] Adjunct Research Fellow, School of Archaeology, University College Dublin, Dublin 4, Ireland.

[e] NERC Isotope Geosciences Laboratory, British Geological Survey, Keyworth, Nottingham, UK

[f] Department of Archaeology, University of Nottingham, Nottinghamshire, NG7 2RD, UK

Abstract

The Anglo-Normans first introduced fallow deer (*Dama dama*) to Ireland in the thirteenth century, however no biomolecular research has previously been undertaken to examine the timing, circumstances and impact of the arrival of this species. This study combines historical, zooarchaeological, genetic and isotopic data from both medieval and post-medieval samples to address this lack. The paper identifies a peak in the presence of fallow deer between the thirteenth and fourteenth centuries, with a corresponding peak in documentary evidence for their presence in the thirteenth century. The deer are predominantly male, and from castle sites, supporting the historical evidence for their link with elite hunting. The English origin of the source populations shows correspondence between the documentary evidence, suggesting a western bias, and genetic evidence, with a similarity to southern and western England. Furthermore, isotopic study identifies two possible first-generation imports, one dating from the medieval and one from the post-medieval periods.

Introduction

As is the case with many islands, Ireland's modern mammalian fauna contains a high proportion of introduced animals, Lever (2009) listing 14 naturalised species. These have gradually replaced Ireland's 'native' species, several of which, including for example grey wolf (*Canis lupus*) and brown bear (*Ursus arctos*), have been brought to extinction (Foster and Chesney 1998, 242). Aside from extinctions, Ireland's list of presumed native species is also diminishing as a result of biomolecular research: recent studies have revealed that some animals that were traditionally assumed to be autochthonous, for example red deer (*Cervus elaphus*) and wild boar (*Sus scrofa*), are, in fact, Neolithic and Mesolithic imports, respectively (Carden 2012; Carden *et al*. 2012). Whilst the non-native status of these wild animals is somewhat surprising, the introductions of other alien species are well documented, having occurred during the historic era. For instance, documentary and zooarchaeological evidence have established that the fallow deer (*Dama dama*) was imported to Ireland during the medieval period (McCormick 1991; 1999; Beglane 2015a, 23-37; 2015b). Prior to their importation to Ireland, fallow deer were restricted to England and Wales and to the Mediterranean (Fig. 1). Given the restricted global distribution of *Dama dama* at this time, the source population was most likely England, where fallow deer had been maintained as an exotic species within the parks since the eleventh century (Sykes and Carden 2011). It is thought that the Anglo-Norman elite introduced both the fallow deer and the concept of parks to Ireland as a package (McCormick 1991; 1999; Beglane 2015a, 23-37; 2015b). This elegant species is now a feature of the Irish landscape, with some populations continuing to be kept in parks, for example, the iconic herd of Phoenix Park, Dublin (Pl. 1), whilst others are raised on deer farms or have escaped to live ferally across the island (Carden *et al*. 2011).

Since the history of Irish fallow deer is considered to be 'known', there has been no biomolecular research akin to that for red deer or wild boar to explore the precise timing, circumstances and impact of the arrival of this species. Yet detailed cultural-scientific research concerning the arrival of fallow deer to other islands such as Britain (Sykes *et al*. 2011, Sykes *et al*. 2016), Mallorca (Valenzuela *et al*. 2016), Crete (Harris 2014), Rhodes (Masseti 2002) and Barbuda (Perdikaris *et al*. 2017) has highlighted the rich, and often unexpected, information that such studies can provide. With this in mind, and to expand existing knowledge of this culturally important species, this paper presents the results of a multidisciplinary investigation of Ireland's fallow deer, combining four independent lines of evidence: historical, zooarchaeological, stable isotope and genetic analysis.

Materials and methods

Beglane (2010a; 2010b; 2015a; 2015b) has previously reviewed the historical and zooarchaeological evidence for the introduction of fallow deer, which is summarised below. This research formed the basis of our analysis. Site locations and datasets are summarised in Table 1 and Fig. 2.

Zooarchaeological methods

All known zooarchaeological records of fallow deer were synthesised and their percentage representation was calculated for each assemblage (Table 1). Material from six sites was available for further analysis: Newtownstewart Castle, Co. Tyrone, Greencastle, Co. Down, Trim Castle, Co. Meath, Cornmarket Street, Dublin City, Cratloemoyle, Co. Clare and Kilkenny Courthouse. This was examined for evidence of pathology and taphonomy (e.g. burning, butchery, gnawing) with their ageing data and osteometrics also being recorded (Table 2). In recognition that the osteometrics could be made more meaningful if viewed against a baseline derived from modern animals of known age and sex, measurements from 227 fallow deer (119 male and 108 female) from Phoenix Park, Dublin, Ireland were used for comparison. These data can be accessed via the *Dama* International Project's on-line database http://www.nottingham.ac.uk/zooarchaeology/deer_bone/search.php. These modern data not only facilitate comparison with raw archaeological measurements but also offer an important opportunity to make the disparate archaeological dataset comparable through the calculation of log ratios. The methods and benefits of log ratios are discussed in detail elsewhere (e.g. Sykes *et al*. 2013). In this study, average measurements from skeletally mature adult individuals from the Phoenix Park population (male average plus female average divided by two) were used as the standard to calculate the log ratios for the bone widths of the archaeological fallow deer.

Following zooarchaeological recording of the specimens, a subset of samples was used for isotope and genetic analysis. These included samples from Greencastle, Trim Castle, Cratloemoyle, Kilkenny Courthouse, Newtownstewart and Cornmarket St, Dublin (Table 1). The data from the Irish specimens were compared to medieval fallow deer from England, the dataset for which is published in Sykes *et al*. (2016). This article provides full details of the analytical methods that were employed for this study but they can be summarised as follows.

Genetic analysis

All DNA analyses were carried out at the Department of Biosciences, Durham University. Ancient DNA was extracted and amplified by Polymerase Chain Reaction (PCR). The process of PCR produces a large number of DNA copies from a single DNA template to produce a readable sequence of DNA base pairs (A,C,G and T). In this analysis, a small sub-section of the mtDNA control region, totalling 532 base pairs in length, was examined. The 532 base pairs were compared across 17 medieval and post-medieval Irish samples. Alignment of each sample sequence allows relationships to be assessed. These samples were aligned to 78 medieval English samples previously described in Sykes *et al.* (2016). The relationship amongst haplotypes (the total number of unique sequences across the samples) was examined by constructing a median joining network. The resulting data provided an assessment of matrilineal diversity within and between sample sites, together with an indication of the demographic history of sampled populations.

Isotope analysis

In order to consider issues of fallow deer diet and, potentially, management, carbon and nitrogen isotope analysis was conducted for the largest available samples of *Dama* remains: those from Trim Castle and Greencastle, as well as from Cratloemoyle. Whilst $\delta^{13}C$ and $\delta^{15}N$ data are generally not, for good reasons, used in provenancing studies, fallow deer stable isotope ratios, particularly carbon, do vary significantly across wide geographical ranges (Miller *et al*. 2016) and have the potential to highlight the presence of first-generation imports to Ireland. To explore this issue in more detail, $\delta^{13}C$ and $\delta^{15}N$ data for modern fallow deer from Ireland and Britain were sampled to ascertain how environmental variations between the two islands might be expressed isotopically. All analyses were undertaken at the NERC Isotope Geosciences Facilities at the British Geological Survey, Keyworth.

Results and Discussion

New zooarchaeological information, genetic data and isotope results were obtained for a total of 31 specimens from the sites under consideration. These results are shown, by site and specimen, in Table 2. Before these data are examined in detail, it is important to first review the findings of the historical and zooarchaeological synthesis.

Historical and zooarchaeological representation

The Greeks and Romans maintained parks filled with a range of animals such as deer, wild pigs, wild goats and wild sheep. These could be extravagant features, such as the *c*. 34 acre park owned by Quintus Hortensius at Laurentum, south of Rome that contained a dining room from which diners could view animals that were summoned by blowing a horn (Jennison 2005, 133-6; Toynbee 1973, 16). These Roman parks and the fallow deer within them spread across the Empire, with fallow deer present, for example, in southern England (Sykes et al. 2006). Although they went into decline in the post-Roman period, parks did continue to be used and created. For example, Charlemagne had one containing 'multitudes of antlered stags' (Allsen 2006, 40), a deliberate imitation of a Roman status symbol used as a means of legitimising this new imperial power (Andrén 1997, 470). During the Norman period, probably in the late-eleventh or early twelfth century, the zooarchaeological evidence suggests that fallow deer were reintroduced to England directly from the Mediterranean, most likely from the Norman island of Sicily (Sykes and Carden 2011) (Fig. 1).

Documentary evidence shows that fallow deer, and the parks in which they were kept, were introduced to Ireland by the Anglo-Normans. The earliest record of fallow deer definitely bound for Ireland is in 1225, when William, Earl Marshal, received a gift of 20 females 'to convey them to

Ireland' *(CDI*, i, no. 1323). However, some years earlier, in 1213, the Archbishop of Dublin was granted 30 fallow deer from Brewood Park, near Coventry in England (*CDI*, i, no. 477). Henry had recently been appointed to the See of Dublin and it is tempting to surmise that these animals were imported to Ireland along with his household (Beglane 2015a, 47-8).

In England, where park creation reached its apogee, fallow deer were the main species kept within medieval parks (Rackham 1987, 125). In Ireland, evidence for both parks and fallow deer is much more limited; there is evidence that hunting and the consumption of venison was less important to the elite there, and it is likely that many medieval parks did not contain fallow deer. This species did not filter down the social scale below the first tier of the Anglo-Norman elite, and instead many of the parks established became preserves for timber and cattle (Beglane 2015a, 191-2; Beglane 2015b). Nevertheless, where fallow deer were introduced, they were well suited to the park environment and parks functioned as live larders as well as venues for hunting (Fletcher 2011, 97-103; Cummings 1988, 48-9, 53-5). For elite hunters, deer could be hunted *par force*, which meant that a single animal was tracked using a scenting dog, called a lymer, and then chased using greyhounds. Alternatively, deer could be hunted using 'drive', 'ambush' or 'bow and stable' methods. In all of these cases beaters drove a group of deer towards waiting hunters, who then used spears or bows and arrows to bring down their quarry. This latter method was suitable for use in larger parks, or, if deer were deliberately released, then a longer drive or a *par force* chase was possible. Professional parkers also used nets and fences to trap deer for live transport or for the provision of venison (Gilbert 1979, 54; Cummings 1988, 32-72; Beglane 2015a, 43-4).

Fig. 3 shows the zooarchaeological representation of fallow deer through time. It can be seen that with the exception of Maynooth Castle, where an early fifteenth-century sample has the largest proportion of fallow deer bones anywhere in Ireland, the highest frequency of the species is between the thirteenth and fourteenth centuries. Most are found at castles, but even in such contexts fallow deer represent only a small proportion of the assemblages. The same overarching pattern is demonstrated by the frequency of documentary references to fallow deer and parks in Ireland (Fig. 4). These also appear in the thirteenth century, reach a peak in the 1250s but then diminish, and reference rare in fourteenth-century documents.

A number of the documentary references relate to royal movements of deer or gifts to Irish magnates and as such these often contain information concerning the source of Irish populations (Beglane 2015a, 47-8):

1213 – Henry, Archbishop of Dublin, thirty fallow deer from Brewood (Staffordshire)

1225 – William, Earl Marshal, twenty does from Cheddar (Somerset)

1234 – Luke, Archbishop of Dublin, five deer from Wychwood (Oxfordshire) and five from Bardfield (Essex)

1242 – Justiciar of Chester (Cheshire) to send sixty fallow deer to Ireland

1244 – Eighty fallow deer moved from Chester (Cheshire) to the royal forest at Glencree

1244 – Maurice FitzGerald, Justiciar of Ireland, six fallow deer from Wirral (Cheshire)

1251 – John FitzGeoffrey, Justiciar of Ireland, three bucks from the Forest of Dean (Gloucestershire)

1275 – Roger de Mortuo Mari, four does from the forest of Pember (Hampshire), twenty-four bucks from the park and forest of Dudley (West Midlands)

1279 – Roger de Mortuo Mari, ten bucks from the Forest of Dene (Gloucestershire)

1291 – John, Archbishop of Dublin, twelve fallow deer from Windsor (Berkshire)

It is noticeable that the majority of the recorded English source populations are located to the west of the country, which is perhaps unsurprising given the destination of the deer: sourcing them as close to Ireland as possible would have reduced transport costs. The origins of Ireland's founding populations can be examined further through genetic analysis, especially since some of the locations mentioned in the historical accounts – Cheddar, Dudley and Wychwood (near Eynsham, Oxfordshire) – are represented in our English aDNA dataset (Sykes *et al*. 2016).

Demographics

Demographics were analysed on samples that gave a positive genetic result (Table 2). Due to the limited sample size, there are insufficient data to gain a detailed understanding of how Irish fallow deer herds were managed. Dental ageing was not possible since no mandibles were recovered; however, examination of the state of epiphyseal fusion of the post-cranial bones shows that the majority of these derived from skeletally mature individuals (Table 2). This age profile is to be expected given that fallow deer were recent arrivals to Ireland at this point and must have been deemed rare exotica, more important to be maintained and displayed alive than consumed. This is also indicated by the log-ratio distribution (Fig. 5), which provides an indirect measure of sex, being skewed towards the positive end of the scale, suggesting an over-representation of larger individuals, which are likely to be males. It has been argued elsewhere (Sykes and Carden 2011; Sykes *et al*. 2016) that a predominance of males suggests an emphasis on the display of large adult bucks within parks, their antlers rendering them a decorous addition to the landscape. However, elite medieval hunting cultures also tended to focus upon the capture and consumption of prime-aged male animals, as they were perceived to be a more noble quarry than female deer (Cummins 1988). An elite preference for hunting male fallow deer would, therefore, explain their over-representation in high-status assemblages.

Genetics

DNA analysis determined that one of the purported fallow deer specimens (434 from Trim Castle: McCormick and Murray 2011) was in fact red deer (*Cervus elaphus*). Male fallow deer are similar in size and form to female red deer and it is not always possible to separate these based solely on visual examination, especially in the case of fragmentary specimens. A number of other samples from Trim Castle (433, 438, 441 and 528) failed, as did specimen 431 from Cratloemoyle, probably due to poor DNA preservation, a common problem when working with ancient DNA. Excluding these specimens, DNA was extracted and successfully amplified for 532 base pairs from 17 samples (Table 2). Fig. 6 shows the median joining network, which depicts the relationship between the haplotypes detected in the medieval populations from England and all samples from Ireland.

Most of the Irish specimens share haplotypes that are common in medieval England (seq_1 and seq_2), while two other Irish haplotypes (seq_3 and seq_4) are within one mutational step from the most common English haplotype (seq_1). Sequences 1 and 2 include some of the earliest-dated *Dama* specimens from England, namely those from the eleventh- to twelfth-century assemblages from Carisbrooke Castle (Isle of Wight), Faccombe Netherton (Hampshire), Goltho (Lincolnshire) and Dudley Castle (West Midlands). None of the Irish samples share haplotypes that are found exclusively in northern or eastern England (seq_5, seq_6, seq_10, seq_13, seq_15), which may support the suggestion from the historical evidence that most deer were sourced from western and southern locations.

Only haplotypes 1-4 are found in Ireland, out of 17 haplotypes identified among all English and Irish regions sampled. We can use a binomial test to assess the probability that this would happen by chance if the same Irish sample size (17) was drawn from the north and south of England independently, given their respective haplotype proportions. Among the 30 northern English samples (from Goltho, Hungate York, Binchester and Belton House), 56% are haplotypes 1-4 (found in Ireland), and 44% are not. That means the probability of sampling a 'non-Irish' haplotype is 0.44. For the south (Sparsholt Villa, Cheddar Palaces, Faccombe Netherton, Carisbrooke, Hyde Abbey, Lewes Castle and Eynsham Abbey) this probability is 0.11. From the binomial test, the probability of drawing only haplotypes 1-4 from the north would therefore be p=0.00005. The same analysis for the south gives p=0.14. So, we can accept the null hypothesis that the Irish sample could have been drawn from the south, but it is unlikely to have been drawn from the north. Dudley Castle is geographically in between these regions, and based on historical data a possible origin; however, the haplotype distribution there is most similar to the north (53% 'non-Irish' haplotypes). Of course, this test is based on a small sample size from the English distributions, and if one or more small founder events established the Irish population, this could have distorted haplotype frequencies.

Isotope analysis

Issues of translocation can also be considered through stable isotope analysis, especially since Miller *et al*. (2016) established that English populations of fallow deer through time are significantly different in $\delta^{13}C$ to those from Ireland (Mann–Whitney *post hoc* pairwise comparisons: $U = 209$, $P < 0{\cdot}05$ two-tailed). This is likely to be due to broad differences in temperature, rainfall and vegetation regimes across the two islands, resulting in local environmental conditions that influence the diet, and thus dietary isotope values, of the fallow deer.

To further support the idea that it is possible to broadly separate fallow deer bone collagen values according to wider regional locale by analysing their $\delta^{13}C$ values, we compare isotope values of modern fallow deer from Phoenix Park, Dublin, and those published from Wytham Woods, Oxfordshire (Bonafini *et al*. 2013) (Fig. 7). These results show that the modern Phoenix Park fallow deer tend to be more negative in $\delta^{13}C$ than those from Wytham Woods. In terms of $\delta^{15}N$ there is less clear separation, as observed in Miller *et al*. (2016), but the trend is for more positive values in the Irish sample when compared to the English fallow deer values.

It is with these trends in mind that we consider the $\delta^{13}C$ and $\delta^{15}N$ bone collagen isotope values of the fallow deer and other cervids from Trim Castle, Greencastle, Cratloemoyle (n= 13, Table 2), and those from medieval English sites (Sykes *et al* 2016) (Fig. 8). The archaeological specimens from Ireland and England (Fig. 8) show more overlap in distribution than is exhibited by the modern populations (Fig. 7). Despite this, the trend shown by the modern samples, with Irish specimens returning more negative values in $\delta^{13}C$ than those from England, is exhibited by the ancient material. The difference between these results, from two adjacent countries separated only by a narrow sea, is significant (Miller *et al* 2016). This offers the possibility of identifying first generation imports amongst the Irish specimens, with the caveat that, at present, there are still few *Dama* results from

Irish sites and more data are needed regarding the isotope ecology of Irish archaeological fauna as a whole.

Specimen TC433 stands out as anomalous, with an exceptionally high N value, but it is noteworthy that this specimen was pathological (see Table 2), which is known to inflate $\delta^{15}N$ values (Katzenberg and Lovell 1999). Beyond this, all the Greencastle specimens and the majority of the those from Trim Castle have the lowest $\delta^{13}C$ values in the distribution, which is consistent with the individuals either having been raised in Ireland, or at least having lived there for several years prior to death. There are two exceptions: specimen TC445 from Trim Castle, with a $\delta^{13}C$ value of -22.2, and the specimen from Cratloemoyle are well within the range expected for English fallow deer. The rate of turnover for $\delta^{13}C$ and $\delta^{15}N$ values in fallow deer bone collagen is unknown, but it is estimated at between 10-30 years in humans (Libby *et al*. 1964, Stenhouse and Baxter 1976). Given this time-lag, and knowing from historical evidence that fallow deer were frequently brought to Ireland from England, the isotope data are consistent with the possibility that these individuals are first generation imports.

Specimen TC445 from Trim Castle is dated to the late thirteenth to early fourteenth centuries, and it is tempting to suggest that it represents the introduction of new bloodstock to Trim's park when the castle changed hands in 1307. At that time Geoffrey de Geneville retired from his position as lord of Trim, leasing his lands to Roger Mortimer (Hartland 2001, 472). Dating to the sixteenth to eighteenth centuries, the Cratloemoyle specimen is much later and is coincident with a second wave of deer introductions which occurred during the post-medieval and early modern periods. This took place as a result of the various plantations of English and Scottish settlers during the sixteenth and seventeenth centuries and the subsequent fashion for landscaped amenity parks in the eighteenth and nineteenth centuries (Beglane 2015a, 184-7, 193; Costello 2015, 164-71).

Conclusion

Biomolecular analyses of all available archaeological fallow deer from Ireland have revealed that Irish populations were most probably drawn from those established in southern and western, rather than northern, England, a pattern consistent with the documentary evidence. Amongst the material analysed, two specimens, one from Trim, the other from Cratloemoyle, appear to be first generation imports as their carbon and nitrogen isotope values are more consistent with English deer. Specimen TC445 from Trim Castle is one of the earlier examples, dated to thirteenth/fourteenth centuries, the period in which both zooarchaeological and historical evidence suggest the greatest levels of deer importation and emparkment (Figs 3 and 4).

When fallow deer were first introduced to Ireland, they would have been valuable and exotic creatures. It would therefore have been important to prevent them from being poached and to ensure that they had sufficient fodder during the winter months. As a result, there is a strong association between the recorded ownership of fallow deer and of medieval parks (Beglane 2015a, 23-37; 2015b). While parks and fallow deer became ubiquitous in England, the same is not true in Ireland, where relatively few medieval parks were created and where there are few documentary records or zooarchaeological samples of fallow deer (Beglane 2010a; 2015a). It has been argued that the relative lack of evidence for fallow deer and for parks in Ireland, and the fall off in their numbers in the late medieval period reflect economic, political and cultural differences between Ireland and England (Beglane 2015a, 45, fig.16, fig.17, 192).

Records for fallow deer, both historical and zooarchaeological, become sparse after the fourteenth century but there are sporadic occurrences of the species in the post-medieval and early modern period. The various post-medieval plantations of English and Scottish settlers into Ireland, and the subsequent development of landscaped amenity parks to surround great houses, saw renewed interest in the development of parks (Beglane 2015a, 184-7, 193; Costello 2015, 164-71). As a result, fallow deer had a renaissance in post-medieval and early modern times. The sixteenth- to eighteenth-century specimen from Cratloemoyle may represent this later wave of fallow deer introduction.

Although separated by several hundred years, Ireland's waves of fallow deer introduction are united by their symbolism. In both cases the introduction of fallow deer, and the parks in which they were housed, formed part of a 'vocabulary of power' utilised by a colonial elite to legitimise their rule over the local population. It is interesting to note that this same vocabulary has been employed by colonial powers for millennia. Starting with the Romans but repeated by the Byzantine, Norman, Anglo-Norman and British Empires, all used the establishment of both fallow deer and parks as symbols of dominance (Perdikaris *et al*. 2017). This study has demonstrated the rise and subsequent fall in the medieval fallow deer population, and through genetics has highlighted their failure to become established, necessitating reintroduction in the post-medieval period. This mirrors the historical evidence for the progress of English control over Ireland, showing how zooarchaeological evidence for a single species can shed light on broad social and political issues.

Acknowledgements

This work was supported by the British Arts and Humanities Research Council [grant numbers AH/I026456/1]. The authors acknowledge the contribution of the zooarchaeologists and excavators who provided samples and access to unpublished data for this project, their reports are listed in bibliography. Fiona Beglane acknowledges the support of the Centre for Environmental Research Innovation and Sustainability, Institute of Technology, Sligo.

Bibliography

Allsen, T.T. 2006 *The royal hunt in Eurasian history.* Philadelphia. University of Pennsylvania Press.

Andrén, A. 1997 Paradise Lost: Looking for deer parks in medieval Denmark and Sweden. In H. Andersson, P. Carelli, and L. Ersgård, L (eds) *Visions of the past: Trends and traditions in Swedish medieval archaeology. Lund studies in medieval archaeology 19,* 469-90*.* Lund. Central Board of National Antiquities.

Beglane, F. 2005 The faunal material. In R. Ó Baoill, Excavations at Newtownstewart Castle, County Tyrone. *Ulster Journal of Archaeology* **64**, 95-102.

Beglane, F. 2007 Report on Faunal Material from Greencastle, Co. Down, 057:003, Licence No. AE/01/13. Unpublished report for Centre for Archaeological Fieldwork, Queens University.

Beglane, F. 2010a Deer and Identity in Medieval Ireland. In A. Pluskowski, G.K. Kunst, M. Kucera M. Bietak and I. Hein (eds.), *Animals as Material Culture in the Middle Ages 3: Bestial Mirrors: Using Animals to Construct Human Identities in Medieval Europe, 77-84. Viavias 3.* Vienna. Vienna Institute of Archaeological Science.

Beglane, F. 2010b Deer in medieval Ireland: Preliminary evidence from Kilteasheen, Co. Roscommon. In T. Finan (ed.), *Medieval Lough Ce: History, Archaeology, Landscape,* 145-58. Dublin. Four Courts.

Beglane, F. 2015a *Anglo-Norman parks in medieval Ireland.* Dublin. Four Courts Press.

Beglane, F. 2015b The social significance of game in the diet of later medieval Ireland. *Proceedings of the Royal Irish Academy* **115**C**,** 167-96.

Bonafini, M., Pellegrini, M., Ditchfield, P. and Pollard, A.M. 2013 Investigation of the 'canopy effect' in the isotope ecology of temperate woodlands. *Journal of Archaeological Science* **40(**11), 3926-3935.

Butler, V. 1989 Animal bone studies in archaeology. *Archaeology Ireland* **3**(3), 104-7.

Butler, V. 1995 Preliminary report on the animal bones from Dunamase, Co. Laois, 93E150. 1994 season. Unpublished report for Brian Hodkinson.

Butler, V. n.d.-a Preliminary report on the animal bones from Dunamase, Co. Laois, 93E150. 1997 season. Unpublished report for Brian Hodkinson.

Butler, V. n.d.-b Preliminary Report on the mammal bone from Waterford City. Railway Square (E294). Unpublished report.

Carden, R. F. 2012 Review of the Natural History of Wild Boar (*Sus scrofa*) on the island of Ireland. Unpublished report for the Northern Ireland Environment Agency, Northern Ireland, UK, National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland and the National Museum of Ireland–Education and Outreach Department.

Carden, R.F., Carlin, C.M., Marnell, F., McElholm, D., Hetherington, J. and Gammell, M.P. 2011 Distribution and range expansion of deer in Ireland. *Mammal Review*, **41**(4), 313-25.

Carden, R.F., McDevitt, A.D., Zachos, F.E., Woodman, P.C., O'Toole, P., Rose, H., Monaghan, N.T., Campana, M.G., Bradley, D.G. and Edwards, C.J. 2012 Phylogeographic, ancient DNA, fossil and morphometric analyses reveal ancient and modern introductions of a large mammal: the complex case of red deer (Cervus elaphus) in Ireland. *Quaternary Science Review* **42,** 74-84.

Costello, V. 2015 *Irish demesne landscapes 1660-1740*. Dublin. Four Courts Press.

Crabtree, P. and Ryan, K. 2009 Faunal remains. In C. Manning (ed.), *The history and archaeology of Glanworth Castle, Co. Cork: Excavations 1982-4*, 117-22. Dublin. Stationery Office.

Cummins, J. 1988 *The hound and the hawk: the art of medieval hunting*. London. Phoenix Press.

Denham, S. and Murray, E. n.d. The animal bones from medieval and post-medieval contexts at Carrickmines Castle, Co. Dublin. Unpublished report.

Duffy, S. 2010 From castle to gaol: analysis of the animal bones from Kilkenny Courthouse, Kilkenny, Ireland. Unpublished MA thesis, University of Southampton.

Fletcher, J. 2011 *Gardens of earthly delight.* Oxford. Windgather.

Foster, J.W., and Chesney, H.C. 1998 *Nature in Ireland: a scientific and cultural history*. Montreal. McGill-Queen's Press.

Friedli, H., Lötscher, H., Oeschger, H., Siegenthaler, U. and Stauffer, B. 1986 Ice core record of the 13C/12C ratio of atmospheric CO2 in the past two centuries. *Nature* **324**(6094), 237-8.

Harris, K. 2014 The social role of hunting and wild animals in late Bronze Age Crete: a social zooarchaeological analysis. Unpubished PhD thesis, University of Southampton.

Gilbert, J.M. 1979 *Hunting and Hunting Reserves in Medieval Scotland.* Edinburgh. John Donald.

Hartland, B. 2001 Vaucouleurs, Ludlow and Trim: the role of Ireland in the career of Geoffrey de Geneville (*c*. 1226-1314). *Irish Historical Studies* **32**(128), 457-77.

Holmes, M. 2009 LSRII - E2083_TVAS: Animal bone. Unpublished report for TVAS Ltd.

Katzenberg, M.A. and Lovell, N.C. 1999 Stable isotope variation in pathological bone. *International Journal of Osteoarchaeology* **9**, 316-24.

Jennison, G. 2005 *Animals for show and pleasure in ancient Rome.* Philadelphia. University of Pennsylvania Press. Originally published 1937.

Lever, C. 2009 *The naturalized animals of Britain and Ireland*. London. New Holland.

Libby, W.F., Berger, R., Mead, J.F., Alexander, G.V. and Ross, J.F. 1964 Replacement rates for human tissue from atmospheric radiocarbon. *Science* **146**(3648), 1170-2.

MacManus, C. 1995 A study of excavated animal bones from C13th to C18th Dublin, Unpublished undergraduate thesis, Dept of Archaeology and Palaeoecology, Queen's University, Belfast.

Massetti, M. 2002 *Island of deer: natural history of the fallow deer of Rhodes and the vertebrates of the Dodecanese (Greece)*. Rhodes. City of Rhodes Environment Organisation.

McCormick, F. 1991 The effect of the Anglo-Norman settlement on Ireland's wild and domesticated fauna. In P. J. Crabtree and K. Ryan (eds). *MASCA Research Papers in Science and Archaeology. Supplement to Volume 8,* 40-52. Philadelphia, MASCA. The University Museum of Archaeology and Anthropology, University of Pennsylvania.

McCormick, F. 1997 The Animal Bones. In M.F. Hurley and O.M.B. Scully (eds.), *Late Viking Age and Medieval Waterford*, 819-53. Waterford. Waterford Corporation.

McCormick, F. 1999 Early evidence for wild animals in Ireland. In N. Benecke (ed.), *The Holocene History of the European Vertebrate Fauna*, 355-71. Berlin. Verlag Marie Leidorf.

McCormick, F. 2004 The mammal bone. In A. Hayden Excavation of the medieval river frontage at Arran Quay, Dublin. In S. Duffy (ed), *Medieval Dublin V.* 221-41. Dublin. Four Courts Press.

McCormick, F. 2010 Appendix IV: the faunal remains. In A. Lynch (ed.), *Tintern Abbey, Co. Wexford: Cistercians and Colcloughs. Excavations 1982-2007,* 227-32. Archaeological Monograph Series 5. Dublin. Dept of Environment, Heritage and Local Government.

McCormick, F. n.d. The mammal bones from Ferrycarrig, Co. Wexford. Unpublished report.

McCormick, F. and Murray, E. 2011 Animal Bones. In A. Hayden (ed.), *Trim Castle, Co. Meath: Excavations 1995-8,* 421-33. DAHG Archaeological Monograph Series no. 6. Dublin. Dept of Arts Heritage and the Gaeltacht.

Miller, H., Carden, R. F., Evans, J., Lamb, A., Madgwick, R., Osborne, D., Symmons, R. and Sykes, N. 2016 Dead or alive? Investigating long-distance transport of live fallow deer and their body parts in antiquity. *Environmental Archaeology* **21(**3), 246-59.

Murphy, E. 1999 Osteological report on the mammal bones from Patrick Street/Pudding Lane, Kilkenny, (Licence 98E0092). Unpublished report for Judith Carroll and Co.

Murray, E n.d. Faunal remains from Maynooth Castle. Unpublished report.

Perdikaris, S., Bain, A., Grouard, S., Baker, K., Gonzalez, K., Hoelzel, A.R., Miller, H., Persaud, R. and Sykes, N. 2017 From icon of empire to national emblem: new evidence for the fallow deer of Barbuda. *Environmental Archaeology* http://dx.doi.org/10.1080/14614103.2017.1349027. 1-9.

Rackham, O. 1987 *The History of the Countryside.* London. J.M. Dent and Sons.
Stenhouse M.J. and Baxter M.S. 1976 The uptake of bomb 14C in humans. In: R. Berger and H.E. Suess (eds), *Radiocarbon dating,* 324-41. Berkeley. University of California Press.

Sweetman, H S (ed.) 1875-1886 *Calendar of documents relating to Ireland, 1171-1307* (5 vols). London. Longman.

Sykes, N., White, J., Hayes, T.E. and Palmer, M.R. 2006 Tracking animals using strontium isotopes in teeth: the role of fallow deer (Dama dama) in Roman Britain. *Antiquity* **80,** 948-59.

Sykes, N.J., Baker, K.H., Carden, R.F., Higham, T.F., Hoelzel, A.R. and Stevens, R.E. 2011 New evidence for the establishment and management of the European fallow deer (*Dama dama dama*) in Roman Britain. *Journal of Archaeological Science* **38**(1), 156-65.

Sykes, N. and Carden, R.F. 2011 Were fallow deer spotted (OE* pohha/* pocca) in Anglo-Saxon England? Reviewing the evidence for *Dama dama dama* in early medieval Europe. *Medieval Archaeology* **55**(1), 139-62.

Sykes, N., Carden, R.F. and Harris, K. 2013 Changes in the size and shape of fallow deer: evidence for the movement and management of a species. *International Journal of Osteoarchaeology* **23**(1), 55-68.

Sykes, N., Ayton, G., Bowen, F., Baker, K., Baker, P., Carden, R. F., Dicken, C., Evans, J., Hoelzel, A. R., Higham, T. F. G., Jones, R., Lamb, A., Liddiard, R., Madgwick, R., Miller, H., Rainsford, C., Sawyer, P., Thomas, R., Ward, C. and Worley, F. 2016 Wild to domestic and back again: the dynamics of fallow deer management in medieval England (*c*. 11th-16th century AD). *STAR: Science & Technology of Archaeological Research* **2**(1), 113-26.

Toynbee, J.M.C. 1973 *Animals in Roman Life and Art.* London. Thames and Hudson.

Valenzuela, A., Baker, A., Carden, R.F., Evans, J., Higham, T., Hoelzel, A.R., Lamb, A., Madgwick, R., Miller, H., Alcover, J.A., Cau, M.Á. and Sykes, N. 2016 Both introduced and extinct: the fallow deer of Roman Mallorca. *Journal of Archaeological Science: Reports* **9**, 168-177.

Whelan, B. 1979 Report on animal bones. In P.D. Sweetman, Archaeological excavations at Ferns Castle, Co. Wexford. *Proceedings of the Royal Irish Academy* **79**C: 244-455.

Ireland's fallow deer: their historical, archaeological and biomolecular records - caption list

Plates

Pl. I: Fallow deer in Phoenix Park, Dublin. © Ruth Carden.

Figures

Fig. 1: Geographical distribution of fallow deer in the eleventh and twelfth centuries, after Sykes and Carden (2011).

Fig. 2: Location map showing sites of fallow deer finds. Numbers relate to Table 1.

Fig. 3: Fallow deer as a percentage of the faunal assemblage through time, data from Table 1. Order of samples is based on earliest possible start date followed by earliest possible finish date for the relevant phase. Data sources per Table 1.

Fig. 4: summary of references to deer/venison being given as gifts to Irish elite or mentioned as being in particular locations in Ireland, after Beglane (2015a, Fig. 17)

Fig. 5. Log ratio distribution for fallow deer from medieval and post-medieval Ireland. Identifications have been confirmed by genetic analysis.

Fig. 6: Median-joining network showing 17 haplotypes found from 17 Irish medieval and post-medieval fallow deer samples from five sites and 78 English medieval fallow deer samples from 12 sites.

Fig. 7. Bone collagen isotope ($\delta^{13}C$ and $\delta^{15}N$) values of modern fallow deer from Phoenix Park, Dublin, Ireland compared with Wytham Woods, Oxfordshire, England after Bonafini et al. (2013). These values have not been corrected for the modern fossil fuel effect (Friedli et al. 1986)

Fig. 8. Bone collagen isotope ($\delta^{13}C$ and $\delta^{15}N$) values of archaeological deer from medieval English and medieval and post-medieval Irish sites. Specimens from Trim and Cratloemoyle marked 'deer' are designated fallow deer by zooarchaeological but not genetic methods.

Tables

Table 1: Sites with fallow deer remains. (Beglane 2005; 2007; Butler 1989; 1995; n.d.-a; n.d.-b; Crabtree and Ryan 2009; Denham and Murray n.d.; Duffy 2010; Holmes 2009; MacManus 1995; McCormick 1997, 837; 2004; 2010; n.d.; McCormick and Murray 2011; Murphy 1999; Murray n.d.; Whelan 1979). Note that sites with only known misidentifications have not been included.

Table 2: Summary of results from sampled sites (Beglane 2005; 2007; Duffy 2010; Holmes 2009; McCormick and Murray 2011; MacManus 1995; Murray n.d.). Within the genetics column Yes denotes those samples where DNA was successfully amplified, Fail denotes those samples where DNA amplification was attempted but unsuccessful and NS denotes samples that were not used. Haplotype numbers correspond to the sequence numbers (1-4) shown in Fig. 6.

No	Site	Dating	NISP	No. of Fallow	% Total assemblage	Metrics	Isotopes	Genetics
Castle Sites - Medieval								
1	Carrickmines Castle, Co. Dublin	Medieval	2407	1	0.04			
2	Dunamase Castle, Co. Laois	Medieval	10966	2	0.02			
3	Ferns Castle, Co. Wexford	Late 13th to early 14thC	156	1	0.64			
4	Ferrycarrig Ringwork, Co. Wexford	13th to 14thC	1026	6	0.59			
5	Greencastle, Co. Down	14thC	311	5	1.61	✓		✓
6	Maynooth Castle, Co. Kildare	Mid 13th to 15th C	844	20	2.37			
6	Maynooth Castle, Co. Kildare	Early 15th C	111	11	9.91			
7	Trim Castle, Co. Meath	Late 13th to early 14th C	2052	23	1.12	✓	✓	✓
7	Trim Castle, Co. Meath	Mid 14th to Mid 15th C	1010	3	0.30	✓	✓	✓
Castle Sites – Post-medieval								
8	Cratloemoyle Co. Clare	16-18th C	391	1	0.26		✓	
9	Glanworth Castle Co. Cork	Post-medieval	860	1	0.12			
10	Kilkenny Courthouse Kilkenny City	18th C	2449	2	0.08	✓		✓
11	Newtownstewart, Co. Tyrone	17th C	123	3	2.44	✓		✓
Ecclesiastical sites - medieval								
12	Tintern Abbey Co. Wexford	13th to 14th C	373	2	0.54			
Urban Sites - Medieval								
13	Arran Quay Dublin City	Late 14th to early 17thC	2327	2	0.09			
13	Cornmarket St. Dublin City	16th C	329	1	0.30	✓		✓
13	Wood Quay Dublin City	13th C	180000	Unknown	-			

10	Patrick St./ Pudding Lane, Kilkenny City	13 to 14th C	5324	5	0.09
14	Peter St. Waterford City	13thC	c.1403	2	0.14
	Urban Sites – Post-Medieval				
14	Railway Square Waterford City	17thC	569	1	0.18

Table 1: Sites with fallow deer remains. (Beglane 2005; 2007; Butler 1989; 1995; n.d.-a; n.d.-b; Crabtree and Ryan 2009; Denham and Murray n.d.; Duffy 2010; Holmes 2009; MacManus 1995; McCormick 1997, 837; 2004; 2010; n.d.; McCormick and Murray 2011; Murphy 1999; Murray n.d.; Whelan 1979). Note that sites with only known misidentifications have not been included.

Sample no.	Site	Date (century AD)	Element	Comments	Metrics	Genetics? Yes/No/ Fail	Haplotype	d13C	d15N	C/N ratio	Yield (mg)	Excavation / Sample details
TC438	Trim Castle, Co. Meath	L13th-E 14th	Metatarsal	Unfused	BP 27.5, DP 28.4, SD 18.3	F		-23.0	6.7	3.4	40.2	95E77 box 49 CBC N3D F10 #6 Sample 1
TC439	Trim Castle, Co. Meath	L13th-E14th	Radius	Fusing	BD 34.9, BFD 33.6	Y	3	-23.0	7.2	3.4	48.5	95E77 box 49 CBC N3D F10 #6 Sample 1
TC440	Trim Castle, Co. Meath	L13th-E14th	Femur		SD 24.6,	Y	2	-22.6	8.1	3.5	63.2	95E77 box 49 CBC N3D F10 #6 Sample 1
TC441	Trim Castle, Co. Meath	L13th-E14th	Femur		SD 18.9	F		-23.3	7.8	3.4	58.7	95E77 box 49 CBC N3D F10 #6 Sample 1

TC442	Trim Castle, Co. Meath	L13th-E14th	Tibia			Y	3					95E77 box 49 CBC N3D F10 #6 Sample 1
TC443	Trim Castle, Co. Meath	L13th-E14th	Metacarpal		SD 18, BD 30.3, B@F 28.3, Dd 18.8, DD 12.2	Y	1	-22.8	7.1	3.4	25.2	95E77 box 49 CBC N3D F10 #6 Sample 1
TC444	Trim Castle, Co. Meath	L13th-E14th	Femur	Unfused		Y	3	-22.3	8.4	3.4	19.3	95E77 box 49 CBC N3D F10 #6 Sample 1
TC445	Trim Castle, Co. Meath	L13th-E14th	Tibia		DP 56.5	Y	2	-22.2	6.2	3.5	27.3	95E77 box 49 CBC N3D F10 #6 Sample 1
TC446	Trim Castle, Co. Meath	L13th-E14th	Calcaneum			Y	3					95E77 box 49 CBC N3D F10 #6 Sample 1
TC528	Trim Castle, Co. Meath	L13th-E14th	Maxilla	Red deer?		F						95E77 box 49 CBC N3D F10 #6 Sample 1
MMI001	Trim Castle, Co. Meath	L13th-E14th	Phal 2		BP 12.7, DP 18.0, BD 10.9, DD 14.6,	NS						95E77 box 49 CBC N3D F10 #6

					Glpe 27.6							Sample 1
MMI 002	Trim Castle, Co. Meath	L13th-E14th	Phal 2		BP 12.6, DP 18.0, BD 11.1, DD 14.7, Glpe 27.5	NS						95E77 box 49 CBC N3D F10 #6 Sample 1
MMI 004	Trim Castle, Co. Meath	L13th-E14th	Tibia		SD 19.2	NS						95E77 box 49 CBC N3D F10 #6 Sample 1
MMI 005	Trim Castle, Co. Meath	L13th-E14th	Femur	Young		NS						95E77 box 49 CBC N3D F10 #6 Sample 1
MMI 006	Trim Castle, Co. Meath	L13th-E14th	Pelvis			NS						95E77 box 49 CBC N3D F10 #6 Sample 1
MMI 007	Trim Castle, Co. Meath	L13th-E14th	Humerus		BD 41.0, BT 35.2	NS						95E77 box 49 CBC N3D F10 #6 Sample 1
TC4 33	Trim Castle, Co. Meath	M14-M15th	Tibia	Pathology	SD 25.5 (estimate)	F		-21.2	10.3	3.4	34.4	95E77 box 49 Sample 2
TC4 34	Trim Castle, Co. Meath	M14-M15th	Metacarpal	Juvenile, gnawed	BP 31.2, DP 22.3, SD 15.3	Cervus elaphus						95E77 box 49 Sample 2
TC4 35	Trim Castle, Co. Meath	M14-M15th	Metacarpal		SD 12.9	Y	1	-23.4	8.3	3.3	72.4	95E77 box 49

												Sample 2
TC437	Trim Castle, Co. Meath	M14-M15th	Metatarsal		no metrics	Y	2					95E77 box 49 Sample 2
GC428	Greencastle Co. Down	14th	Metatarsal		BP 26.6, DP 29.7	Y	1	-22.9	6.7	3.3		AE/01/13 C39 6228
GC429	Greencastle Co. Down	14th	Calcaneum	Burnt		Y	4	-22.7	7.1	3.4		AE/01/13 C39 6304
GC432	Greencastle Co. Down	14th	Metatarsal		BP 28.9	Y	1	-22.9	6.9	3.3		AE/01/13 C66 6389
GC525	Greencastle Co. Down	14th	Metacarpal		BP 31.2, DP 20.9	Y	2					AE/01/13, C43 6422
GC526	Greencastle Co. Down	14th	Metatarsal		BD 29.8, B@F 29.9, Dd 18.2, DD 14.6	Y	1					AE/01/13, C36 6678
HO431	Cratloemoyle Site 1, Co. Clare	16-18th	Calcaneum			F		-22.3	5.5	3.4	44.3	A005 2012 LSIRR Phase II E2083 C455
CO527	Cornmarket St, Dublin City	16th	Metatarsal	Old	BP 29.9, DP 31.6, SD 16.1,	Y	1					93E109, 4:56
NS524	Newtownstewart, Co. Tyrone	17th	Humerus		SD 20.3, BD 41.8, DD 35.5, BT 38.6, HT 25.3 HTC 19.7	Y	1					NSC99 C35 5688
MMI003	Newtownstewart, Co. Tyrone	17th	Metacarpal		GL 197, BP 29.7, DP 20.8,	NS						NSC99 C35 5689

					SD 18.6, BD 30.0, B@F 28.7, Dd 19.2, DD 12.5			
KK430	Kilkenny Courthouse	18th	Femur			Y	2	08E0462 C484 id: KK1496
MMI 008	Kilkenny Courthouse	18thC	Phal 2	Gnawed	BP 14.9, DP 18.8, BD 11.9, DD 17.6, Glpe 28.6	NS		08E0462 C491 id: KK0462

Table 2: Summary of results from sampled sites (Beglane 2005; 2007; Duffy 2010; Holmes 2009; McCormick and Murray 2011; MacManus 1995; Murray n.d.). Within the genetics column Yes denotes those samples where DNA was successfully amplified, Fail denotes those samples where DNA amplification was attempted but unsuccessful and NS denotes samples that were not used. Haplotype numbers correspond to the sequence numbers (1-4) shown in Fig 6.