The Coin Hoards of the Roman Republic database: the history, the data and the potential

Kris Lockyear

noviodunum@hotmail.com

Institute of Archaeology, University College London, 31–34 Gordon Square, London WC1H 0PY

Abstract

The first part of this paper discusses the origins and development of the CHRR database as compiled by the author. The second section provides a couple of examples of the sorts of questions the data can be used to answer by examining two assemblages: the hoard from Mainz and the possible hoard from Alésia. This paper does not particularly discuss the creation of CHRR *Online* which will be examined elsewhere (Gruber and Lockyear2015). It should be noted, however, that CHRR *Online* is derived from the author's database, and will be regularly updated by uploading the data from it.

This paper is dedicated to the memory of Rick Witschonke.

1. Introduction

The title of this paper may remind some readers of the film *The good, the bad and the ugly*. The echo is deliberate. This paper examines the *Coin Hoards of the Roman Republic* (CHRR) database, from which CHRR *Online* hosted by the ANS, has been created (Gruber and Lockyear 2015). A detailed discussion of the CHRR database has been published previously (Lockyear 2007, chapter 2)[1] and the first part of this paper will summarise that discussion and then expand upon some of the issues. The second part of this paper will present two previously unpublished case studies demonstrating the potential of the database and some possible methods of analysis.

2. The CHRR database

I have previously outlined in detail the sources of data used in the construction of the CHRR database, the data manipulation strategies employed, and the structure of the database (Lockyear 2007, chapter 2). I wish here, however, to expand upon some of the wider issues which have impacted on the database.

The CHRR database began as part of an MSc dissertation (Lockyear 1989) and was originally implemented using the RDMS package Ingres on a network of powerful Sun workstations. At that time the database only contained information about the twenty-four hoards published by Crawford

[1]Available from http://numismatics.org/chrr/pages/background.

(1974) in Table L. The database structure was based on that designed by Ryan (1988) for site finds from Roman Britain. It became clear that there was scope to expand the original dissertation into a doctoral thesis (Lockyear 1996b). Although the data was originally moved to Ingres for PC this proved too slow and also could not be run on the only laptop available at that time. As a result the data was imported into dBase III+. A suite of programs were written to ease data entry and manipulate it for analysis. The database grew from twenty-four hoards to 617 containing information about 71,363 coins. No new data were added between 1996 and 2006 at which point the database was imported into Microsoft Access and new hoards began to be appended. The growth of the database can be seen in Figures 1–2. The CHRR database at the time of writing contains some information about 718 hoards containing 120,177 coins of which 106,771 are well identified. Of these 510 hoards have detailed information concerning their contents and 208 only have limited information included in the main FINDSPOT table of the database.

Figures 1 and 2 about here.

The database up to this point is what I have called a *personal research database*. It was created for my particular projects and interests with no intention, at least initially, of making the information publicly available. Conversion of the database to a *resource* database in the form of CHRR *Online* involved not only the technical issues in making the data available across the web, but also in meeting and managing the expectations of the target audience who may well have somewhat different interests than the

creator of the database (Gruber and Lockyear 2015). We have attempted to do this via a process of *informing*, *enhancing* and *enabling*. This paper, along with the information posted on the CHRR *Online* website[2] and the paper by Gruber and Lockyear (2015), forms part of the process of informing. Conversion of the database to an open linked data format and implementation of the webpages by Ethan Gruber constitutes the process of enabling. The enhancement of the database will be discussed below.

What hoards are included in the database? The intended scope of the database matches that of *Roman Republican Coin Hoards* (Crawford 1969, henceforth RRCH). It contains hoards which (a) contain at least one Roman coin and (b) hoards which close with or before the issues of C. L. Caesares (*c.* 2 BC–AD 4). In reality, the coverage is more limited. The original research project centred on patterns in the distribution of *denarii*, and thus pre-*denarius* hoards are largely omitted. Additionally, early anonymous *denarii* are difficult to identify especially from published sources alone. Recent work is going some way to remedy this situation (*e.g.*, Debernardi 2012). The need to have reasonable sized groups of hoards with a narrow range of closing dates and good quality data led to few hoards prior to 157 BC being input to the database. The groups used varied from a maximum of 30 years to a single year and contained between eight and 25 hoards. Similarly, the difficulties in identifying early Imperial issues from older published sources, as well as the lack of hoards of silver *denarii* from Italy of that date, has led to an under-representation of Augustan hoards.

[2] See especially http://numismatics.org/chrr/pages/background.

In general, *denarius* hoards from Italy are well represented as both Crawford (1969, 1985) and Backendorf (1998) have provided excellent information. My research interests coupled with the corpus published by Chițescu (1981) has led to excellent coverage for late Iron Age Dacia. Unfortunately, information from Bulgaria is less well published although the work of Evgeni Paunov is helping to improve the situation. Coverage for the late second century from the Iberian peninsula is excellent as a result of data collection for a forthcoming paper. The principal weak areas are, therefore, early hoards and non-*denarius* hoards.

There are some omissions which initially seem surprising. By way of example, the 'New Italian' hoard, actually found in Sardinia and published by Hersh (1977), is currently omitted as the publication does not include the early issues within the hoard and therefore did not meet the criteria for the original analyses. Problems with the detailed data is the main reason that 208 hoards only have a summary entry in the FINDSPOT table but no detailed information concerning their contents.

One recurrent problem is the consistent identification of hoards. The usual methods used by numismatists are either to cite a corpus number, *e.g.*, RRCH 234 or the find spot plus the date found, *e.g.*, Alife 1937. The problem with the former method is that published corpora have fixed number sequences so new listings create new references, thus El Centenillo (1911) is RRCH 181, Blázquez (1987–1988) No. 26, Chaves Tristán (1996) No. 16 or Villaronga

(1993) No. 77! Consistent identification in a database system is via a field designated the primary key. In this case neither the corpus number (not all hoards have them) or the name plus year (some places such as Rome and Padua have multiple finds) seemed really suitable and so a simple three-letter code has been created for every entry, *e.g.*, ALI for Alife and EL1 the El Centenillo hoard. These codes have been consistently used by the author in previous publications and are used in the online version of the database. They are also used in the second part of this paper. They have the advantage over a simple number in that there is no expectation of the codes reflecting a dating sequence, and also they are generally easier to remember. By asking users of the online resource to use these codes when using the data in their own work, it is hoped they will become the standard method by which hoards are identified.

A few hoards create problems at even this level. The Ancona hoard (RRCH 169 and 344. AN1 and AN2) is held by the American Numismatic Society. Crawford has split this assemblage into two hoards on the basis of its contents although the documentation at the ANS suggests it is one hoard (Crawford *pers. comm.*, Metcalf *pers. comm.*). The structure of this assemblage suggests that Crawford's division into two hoards is basically correct but that he has incorporated some of the tail of the second hoard in with the body of the first (Lockyear 2007, 82). The La Oliva hoard (RRCH 197, OLI and OL2, Chaves Tristán 1996, Nos. 24 and 32) is thought by Crawford to be two lots of the same hoard but is argued to be two separate hoards by Chaves Tristán (1996, 245). Wherever possible, I have kept

disputed hoards like this separate as it is easier to combine listings than it is to split them.

The database design includes a series of 'accuracy' codes which enable one to assess the degree of confidence in the identification of individual coins. The first four codes are based on the levels created by Reece (1975). For Reece, an unqualified reference is definitely a coin of that type, 'as' indicates the first possible reference that a coin may be when it cannot be precisely identified, 'copy of' indicates a copy of a specific coin and 'copy as' indicates a copy like the reference given. In CHRR these four levels are coded 1 to 4. There are, however, instances when a coin can be identified down to an RRC issue, but not down to a specific type. For example, RRC 408/1a and 408/1b are sometimes either published as 408/1 or 408/1a–b. To indicate coins identified to this level the database assigns the accuracy code 5 and CHRR *Online* uses 'as issue…' in its lists. As well as coins which can be given some form of precise reference, there are a number of general categories such as 'miscellaneous Republican asses' or 'Iberian *denarii*'. Coin type numbers have been created for these categories and they are assigned an accuracy code of 8. The remaining codes are explained in Table 1. There are weaknesses with this system. For example, how does one record RRC 408/1a–b when only presence/absence data is available? Up until now, this problem has been irrelevant as hoards with only presence/absence data are of no use in the types of analyses the database was designed to support. With its conversion from research to resource, however, some of these issues will have to be addressed.

Table 1 about here.

The dating of Republican issues is controversial. In Roman Republican Coinage, Crawford (1974) offers quite precise dates for most issues, especially after 157 BC. These dates are not universally accepted and alternative dating schemes have been offered for parts of the sequence; for example those by Hersh (1977), Hersh and Walker (1984) and Mattingly (2004, chapter 13). From the point of view of creating a usable database, these partial sequences are problematic. For example, if one adopts Mattingly's (2004) scheme for the issues from RRC 197 down to the Social War, one ends up with an artificial gap in the dating sequence between Crawford's dates for the earlier issues and Mattingly's. The CHRR database, therefore, uses the dates from RRC by default. A crude but very effective way of incorporating the alternative dating schemes was to simply duplicate the COINTYPE table and then to edit the dates for the affected issues. The database now incorporates two tables with alternative dating schemes taken from Mattingly (2004) and Hersh and Walker (1984) allowing for the impact of the various schemes on the patterns in the hoards to be assessed.

The enhancement of the CHRR database is taking three forms:

1. The addition of additional hoard data to the current database.
2. Importing information from the online version of the database to enhance the 'working' version.
3. The expansion of the scope of the database to include additional areas

of information.

The first of these requires little explanation. Further hoards are added to the database whenever the opportunity arises, and/or hoards already included at a summary listing level have detailed data input as and when possible. At regular intervals the data included in CHRR *Online* will be updated from the master database held by the author. The main change is that hoards not previously prioritised, such as the early material or non-*denarius* hoards are being input in order to improve the function of the database as a general resource for scholars.

The online version of the database varied from the author's working database in that the information regarding coin types was derived from the British Museum's database which contained information regarding designs, legends *etc.* taken from RRC as well as the basic information regarding dates and denominations which had been included in CHRR's COINTYPE table. The British Museum data was incomplete, however, and the missing information was added by the American Numismatic Society. This data was then used to enhance CHRR. The second source of data was that many of the hoard's find spots were automatically located using the Geonames system by Ethan Gruber. Although only accurate down to the level of the named settlement, this basic location information allows CHRR *Online* to map hoards. This information has now been incorporated into CHRR which will allow more formal spatial analyses to be undertaken if desired.

Lastly, two new hoard projects are currently underway: one team at Oxford is building a database of Roman Imperial hoards from outside the UK and a second team from the British Museum and Leicester are looking at hoards from within the UK. Both these projects are recording more generic information about hoards such as the vessels in which they were found, associated artefacts, circumstances of discovery *etc.* rather than the detailed coin-by-coin listings gathered by CHRR. Much of this information for Republican hoards is available in either the CHRR logbooks and archive, or Crawford's archive held by the British Museum. The two Imperial projects are using the same database system, and we are investigating how best to incorporate elements of their system into CHRR in order that the three databases will be compatible and inter-operable.

Although the above discussion has highlighted some of the problems with the data, and looked at how it may be enhanced, it cannot be emphasised too strongly that the database *as is* forms a substantial and significant body of information of enormous use to scholars investigating the coinage of the late Republic. The next section presents two sets of analyses which demonstrate just some of the ways this data may be used.

3 Using the data: two examples

Many analyses using the data from the CHRR database have already been published (*e.g.*, Lockyear 1991, 1993, 1995, 1996a, 1999b, 2007, 2008, 2012). The majority of these previous analyses examine groups of hoards in

order to identify and assess patterning within them. In this section I wish to examine how the data may be used in a slightly different scenario where there are questions relating to a specific assemblage. Two examples are investigated — the Mainz (MNZ) hoard and the assemblage from Alésia, Camp D (ALD) — in order to illustrate the sorts of ways the data can be used to examine specific finds in their broader context. I would like to thank Stéphane Martin for posing such interesting questions about these two assemblages and providing the data from Alésia, Camp D.

3.1 The Mainz hoard

The Mainz hoard consists of only 12 *denarii* and closes in 78 BC according to Crawford's chronology. It is of interest as it was found in Treveran territory but closes some twenty years before the Gallic Wars. It is, however, a very small hoard and thus the closing date is rather unreliable, but how unreliable is it? Additionally, is there anything else exceptional about this hoard?

The data for Mainz was input to the CHRR database from Michael Crawford's notes currently held in the British Museum. The hoard was not analysed previously as its small size falls considerably below the minimum of 30 coins I generally use (Lockyear 2007, 44). This is the earliest hoard from Germany in the CHRR database, and one of only a handful from France and Austria. The late 80s – early 70s BC mark the period of initial penetration of *denarii* into northern Europe as well as eastwards into Romania and Greece. The period 78–75 BC is characterised by a high degree of homogeneity in coin

hoard structure. The large issues of the Social War, which had created such marked patterning in the data for the 80s BC, had circulated sufficiently that hoards of this date are extremely similar to each other (Lockyear 2007, cf. sections 5.4.7 and 5.4.9).

Table 2 about here

Figure 3 about here

A data set of nineteen hoards with twelve or more well-identified *denarii* closing between 78–75 BC was extracted from the CHRR database (Table 2).[3] Of these hoards four fall below the usual thirty coin limit including Mainz (MNZ), two French hoards, Bompas (BOM) and Brusc (BRU) and Puerto Serrano from Spain (PSE). One of the first things to note about this selection is their wide geographical spread. These nineteen hoards come from nine modern countries, a quite unusual distribution at this period when usually Italy, Spain and Romania dominate the data sets.

My usual procedure for analysing a data set such as this is to graph the data as cumulative percentage curves, and to perform Correspondence Analysis (CA), a multivariate statistical technique developed to analyse tables of categorical data such as we have here (Greenacre 2007). The cumulative percentage curves allows one to see the broad patterning in the data by date and are generally easier to interpret than an ordinary line graph with many

[3] 'Good total' refers to the number of denarii that can be accurately identified to an RRC issue, but not necessarily down to an exact RRC reference.

overlapping lines, or by plotting multiple histograms. I have discussed CA in detail previously (Lockyear 2007, 40–64). The aim of CA is to extract from a large data set the underlying trends in the data and it is worth quickly recapping the major aspects of the technique.

1. CA is a technique for analysing tables of non-negative integer data, *e.g.*, counts of coins in hoards or site assemblages.
2. CA calculates scores for every variable and every assemblage on a series of new axes where the first axis represents the main underlying pattern in the data, the second axis represents the next most important source of variation, and so on. In coinage studies, the first axis often represents date (*e.g.*, early to late hoards). Each axis can be said to 'explain' a percentage of the variation in the data which gives an indication of how successful the analysis is in revealing the underlying patterns.
3. The results of the technique are presented as one or more scattergrams, technically called maps as both the *x* and *y* axes should be plotted to the same scale. Usually two maps are produced, both showing axes 1 *v.* 2 but the first representing the assemblages (in our case hoards) and the second representing the variables (in our case coinage issues). More subtle patterns can be observed by examining axes 3 and beyond although in hoard studies these can quickly start representing the variation in only a very small number of issues.
4. Two points on a map plotted close together are likely to be similar in some way, and two points plotted at a distance are likely to be

dissimilar. In our case, two hoards plotted close together are likely to contain a similar range and proportion of coinage issues. Similarly, two issues plotted close together are likely to have a similar distribution across the hoards.

5. By comparing the two maps it is possible to see which issues are particularly related to which hoards, and *vice versa*.
6. The process of calculating the axes and plotting the scores is an attempt to simplify a complex data set. As a result, some items will not fit that simplified pattern. Consultation of the accompanying diagnostic statistics (more properly known as decompositions of inertia) enables one to identify which items (hoards and/or issues) fit the pattern well, and which should be ignored. One of the most useful of the diagnostic statistics is 'quality' which scores out of 1,000 how well a point 'fits' the map. The position of items with a very low quality should not be given any great meaning on that map
7. By comparing the maps and consulting the diagnostic statistics, an interpretation for each axis can be given.

A formal description has of CA been provided by Greenacre (1984) and his later work is a more practical description of the method (Greenacre 2007). The method has been used widely in archaeology (*e.g.*, Pitts and Perring 2006) and coinage studies (*e.g.*, Orton 1997). Baxter and Cool (2010) have provided a useful hands-on description.

The total number of well identified *denarii* in the data set was only 1,106,

a remarkably small number for 19 hoards. As a result, the cumulative percentages curves presented in Fig. 3 are often quite jagged. The graph does show, however, that (a) the majority of the hoards are very similar to each other with the exception of the Bompas hoard which has quite a 'modern' profile; and (b) that the Mainz hoard looks very similar to the rest of the assemblage.

As a result of the small size of most of the hoards, the data set is very sparse with 77% of the cells having an entry of zero. Correspondence Analysis can be badly affected by having comparatively rare issues — by which I mean rare in the current data set — occurring in small hoards. To alleviate this problem, all issues prior to RRC 197 were deleted from the data set, some nineteen coins. Additionally, the four smallest hoards were included in the analysis as supplementary points (Greenacre 2007, chapter 12). This means that the CA map is created without using these four hoards, and then the position of those hoards is calculated and plotted. This process highlighted the fact that four issues only occurred in these smaller hoards: RRC 242, 330 and 343 in the Puerto Serrano hoard (PSE; one example each) and RRC 365 in the Bompas hoard (BOM; two examples). The CA of the complete data set (not presented) is unsurprisingly dominated by the two examples of RRC 365 and the Bompas hoard. These four issues were therefore also deleted from the data set which was then re-analysed. In the second analysis the first axis accounted for 11.9% of the variance in the data, and the second axis 10.3% giving a total of 22.2% for the maps, a very low figure but one which is to be expected given the small size of most of the hoards.

The resulting maps from this analysis (Figs. 4–5) do show some patterning despite the problems. The three Italian sites are plotted in the lower-left quadrant of the map, the majority of the outliers tend to be Romanian or French hoards with the exception of the hoard from Randazzo (RAN). This pattern is very similar to that reported previously (Lockyear 2007, 91–92). As far as the Mainz hoard is concerned, it appears to be similar to Italian, Spanish and Portuguese hoards of this period and is rather unremarkable although the small sample size does need to be taken in consideration when making such a judgement. These maps reinforce the impression given by the cumulative percentage graph discussed above.

Although we now know that the Mainz hoard is unremarkable, structurally, it does not help us assess the problem of the probability that a small hoard closing in 78 BC may actually have been extracted from the coinage pool somewhat later. A method exists by which we may graph the probability of a later closing date (Lockyear 2012, 203–206). This method relies on using the die estimates for Roman Republican coinage (Crawford 1974) as *relative issue size coefficients* (Lockyear 1999a), *i.e.*, indicators of relative rather than absolute issue size. By using the binomial formula and the coinage population figures calculated using a 2% decay rate we can calculate the probabilities for hoards of various sizes. Taking the Mainz hoard as an example, in 77 BC coins struck in that year form 1.9% of the coinage pool. To calculate the probability of a hoard of twelve coins collected in 77 BC *not* containing any coins of that year we use the formula $(1–p)^n$ where p is the

probability, in this case the percentage expressed as a proportion, and *n* is the number of trials, *i.e.*, the size of the hoard. In this case, therefore, we get:

$$(1–p)^n = (1–0{:}019)^{12} = 0{:}98^{12} = 0{:}79$$

We can then calculate the probability for 76 BC using the proportion of the coinage pool dating to 77–76 BC, and then for 75 BC using the proportion for 77–75 BC and so on.

Figure 6 shows the probabilities for coin hoards of the size of the three smallest hoards, along with a hoard of the same size as the Noyer hoard (NOY) for comparison calculated using this method. As can be seen, a hoard the size of Mainz stands a 30% chance of having been collected ten years after its closing date, and a 14% chance of being collected 15 years later. Similar figures hold for hoards the same size as Bompas and Brusc. There is a probability of 0.055, *i.e.*, just over 1 in 20, that the Mainz hoard was collected as late as 58 BC. This is, of course, a 'best case' scenario assuming the hoards were collected from a coinage pool similar to the Italian one which from the CAs appears to be the case. There is no way of knowing precisely the gap between the closing date and the deposition/loss date. It does appear, however, that it is rather unlikely that the Mainz hoard dates to as late as the Gallic Wars, and in the light of these analyses it can be seen as further evidence of the contacts which developed between the Treverii and the Romans in the period 100–50 BC (Martin, *pers. comm.*).

3.2 The Alésia ‘hoard’

Excavations in the 19th century at Alésia ‘Camp D’ retrieved an assemblage of 99 Roman Republican coins, 98 *denarii* and one *quinarius*. The date of the final coin is 55 BC. This assemblage was found scattered along a section of ditch and comprises almost all the silver from the finds associated with the famous siege. It has been suggested by Popovitch (2001, 80–83) that the assemblage could represent a dispersed hoard rather than, for example, a votive deposit.

The data for Alésia Camp D was uploaded to the CHRR database (ALD) and a comparative data set extracted. There are sixteen hoards in the database with thirty or more well-identified denarii dating to the period 56–54 BC and comprising 2,803 coins (Table 3). Previous analysis of hoards of this period showed that the majority of Romanian and Bulgarian hoards were very similar in structure and had a very archaic profile (Lockyear 2007, 107–12). The Italian hoards were slightly more varied and more modern in profile, and the most modern hoard was that from Thessalonica (THS). The current data set adds another hoard from Greece (Macedonia, MC1) as well as the Alésia assemblage.

As noted previously, there are data quality issues with the Ancona hoard (AN1), specifically the lack of early coinage. This hoard has, therefore, been omitted from the cumulative frequency graph (Fig. 7) although it has been retained in the correspondence analyses where it has little impact on the

results. From Figure 7 the similarity between the Romanian and Bulgarian hoards can be clearly seen. The Italian and Greek hoards have more varied profiles but all are more modern in structure than the Romanian/Bulgarian hoards. The assemblage from Alésia is slightly archaic in structure but still more modern than the Romanian and Bulgarian hoards, and is quite similar to the hoard from Compito (COM).

The CA of these sixteen hoards is presented in Figures 8–9. The total variance explained by the first two axes of inertia is 28%, not a very high percentage but acceptable. As expected, the map of sites shows a tight cluster of Romanian and Bulgarian hoards, with a wider spread amongst the remaining hoards. The addition of Alésia and Macedonia has done little to change the overall configuration of the map from the previously published analysis (Lockyear 2007, 107–112). Macedonia has a moderately high quality[4] on this map of 319 whereas Alésia is on the low side with only 90. This, however, compares favourably with the low quality of many of the small Romanian hoards such as Icland (18) or Someșul Cald (17). The Alésia assemblage appears to be very similar to the Italian hoards from Compito (COM), Grazzinese (GRA) and Sustinenza (SUS). The Ancona hoard (AN1) has had its tail artificially truncated hence its position close to the Macedonia and Thessalonica hoards. The location of the Macedonia hoard, the other new addition to this data set, in the same region of the map as Thessalonica is an interesting confirmation of the previously described patterning in the hoards.

[4] 'Quality' is a measure of how well an individual point is represented on the map and is a score out of 1000. See Lockyear (2007, pp. 57–9) for a description of how the diagnostic statistics can be interpreted.

The map of issues (Fig. 9) generally shows the newest issues at the right-hand end of the first axis and the older issues at the left giving a generally old to new gradient across the map. The second axis separates out most of the very newest issues towards the top of the map and the slightly older issues to the bottom right. The second axis is, therefore, highlighting the pattern in the very newest issues of coins in the data set. Comparing the two maps shows the Romanian and Bulgarian hoards with a preponderance of older issues, the Italian hoards and Alésia with more modern profiles but the two Greek hoards being associated with many of the newest issues.

One may enquire why the period 56–54 BC was chosen to select hoards to compare to Alésia. This grouping was originally used simply to create a group of hoards with as small a range of closing dates as possible but in sufficient numbers to allow for analysis (Lockyear 1996b, 149–151).[5] It is likely, therefore, that there are hoards similar in structure to Alésia but with a different closing date. An alternative approach would be to use Dmax-based cluster analysis (Lockyear 1996a), a technique which has been applied successfully to both hoards (Lockyear 2007, 2008) and site finds (Lockyear 2000; Walton 2012). In this case, however, we are not trying to create groups but simply wish to see which hoards are most similar to Alésia. We can do this by calculating the Dmax value (more properly known as the Kolmogorov-Smirnov distance) between Alésia and the remainder of the

[5] In *Patterns and Process* (Lockyear 2007) I divided the available hoards into 22 groups covering the period 147–2 BC. The groups varied in date range from 29 years to a single year, depending on the distribution of closing dates.

hoards in the CHRR database with 30 or more well-identified *denarii*.[6] Dmax is simply the maximum difference between the cumulative proportion curves for two hoards. To illustrate this Fig. 10 presents the curves for Alésia, Compito and Thessalonica. As can be seen, Compito and Alésia are very similar with a Dmax value of 0.08 whereas Thessalonica and Alésia are very different, Dmax is 0.38.

Table 4 presents all those hoards with a Dmax value of less than 0.15. A large number of these hoards are from Romania and date sometime after Alésia. This is unsurprising and reflects the pattern of coinage supply to that region (Lockyear 2008). Of more relevance are the hoards from Italy, France and Spain. The hoard most similar to Alésia is that from Compito included in the CAs discussed above. The rather archaic Piedmonte d'Alife hoard (PIE) is also quite similar, as is San Gregorio di Sassola (GRE) which closes in 58 BC. All in all, the Alésia assemblage looks very similar to Italian hoards of the early 50s BC or archaic profiled hoards closing a little later and would be unremarkable if it were not for the find spot.

Having determined that the Alésia assemblage looks like a perfectly ordinary hoard of the early 50s BC, there is one last possibility to examine. If we assume a hoard is a random collection of coins — in this case *denarii* — from the coinage pool, we can also expect that there will be differences between hoards which is entirely due to chance. This is, of course, why we set a minimum size of hoard for analysis; the smaller the hoard the bigger the

[6] Some 328 hoards as of 16/6/2012.

variation caused by the random selection process. One issue with CA, however, is that it is a purely deterministic technique which represents the data set given without indicating the variation one might expect from random selection. A solution to this is to undertake a bootstrapped CA. In this method, new data sets are created by sampling with replacement from a population defined by the structure of the existing data set and then analysed using CA. This process is then repeated, usually 10,000 times. For each hoard and issue we now have 10,000 data points instead of just one. By plotting ellipses around the points for each hoard or issue, or more usually 95% of them, we can see how much variation we could expect for hoards of that size and structure. Bootstrapped CA is a useful technique and has been used in the analysis of a variety of archaeological assemblages including site finds and Republican coin hoards (Lockyear 2013).

Fig. 11 is the output from a bootstrapped analysis using the method and code developed by Ringrose (2012). The ellipse for Alésia, although larger than the three unproblematic hoards from Italy, clearly lies in the same general region. Comparison with some of the other ellipses, such as that from the Buzău hoard (BUZ) shows that the point for Alésia is relatively stable and we can have confidence it where it is located on the map. If the ellipse was very large we could not be able to have confidence in its location, and thus its interpretation. In this case, the bootstrapped analysis has reinforced our conclusions derived from the other analyses.

In conclusion, the Alésia Camp D assemblage has all the characteristics of

a hoard withdrawn from the Italian coinage pool in the early to mid-50s BC, and although it is impossible to be definitive about it, it appears very likely that it is a dispersed hoard as previously suggested by Popovitch (2001) rather than being a votive deposit.

4 Conclusion

This paper has outlined the history of the CHRR database, and by extension CHRR *Online* (Gruber and Lockyear 2015), as well as explaining the 'quirks' that the database exhibits which are a result of the origin of the database as a research database, not a resource database. A programme of work is underway, generously funded by the late Rick Witschonke, to enhance the database and to iron out many of the issues discussed. These enhancements will, in due course, be carried over to CHRR Online.

The second part of this paper has provided some examples of how the data contained within the database can be used to examine individual hoards against the wider background pattern as revealed by the previous extensive analyses (Lockyear 2007). A variety of different methods were presented, perhaps more than is needed in each case, in order to illustrate the range of techniques which can be applied to this data. The methods chosen are ones that I have found useful in my research, but other analysts may well choose different techniques. Many of the methods are not exclusive to the study of hoards but can usefully be applied to assemblages of site finds such as those collected by Reece (1991) and Walton (2012). Some of the techniques require

the use of statistical packages such as R (*e.g.*, the correspondence analyses) and even bespoke R code (*e.g.*, Dmax-based clustering) whereas other methods such as the use of Dmax as a similarity coefficient can be calculated using a spreadsheet package.

With the current development of databases of Roman Imperial coin hoards, alongside the growing adoption of the sorts of methods discussed here as shown by the creation of *The Journal of Archaeological Numismatics*, we are entering an exciting period for numismatic research. This research will be fuelled by access to large bodies of comparative data along with ever more sophisticated methods of analysis.

Acknowledgements

I would like to thank Stéphane Martin for the stimulating questions posed by the Mainz and Alésia hoards. I would also like to thank Michael Crawford for allowing access to his records now housed in the Department of Coins and Medals**,** and to the many members of the Department past and present for facilitating that access. I am indebted to the late Rick Witschonke for providing the initial impetus for CHRR *Online* and for coordinating its development, as well as funding the current process of updating and expanding the CHRR database. I would also like to thank Ethan Gruber for creating the *Online* version of the database without which the data would not be so widely available.

References

Backendorf, D. 1998. *Römische Münzschätze des zweiten und ersten Jahrhunderts v. Chr. vom italienischen Festland.* Studien zu Fundmünzen der Antike, Band 13. Berlin: Gebr. Mann Verlag.

Baxter, M. J. and H. E. M. Cool. 2010. Correspondence Analysis in R for archaeologists: an educational account. *Archeologia e Calcolatori* 21: 211–228.

Blázquez, C. 1987–1988. Tesorillos de moneda republicana en la península Ibérica. Addenda a Roman Republican Coin Hoards. *Acta Numismática* 17–18: 105–142.

Chaves Tristán, F. 1996. *Los Tesoros en el Sur de Hispania. Conjuntos de denarios y objetos de plata durante los siglos II y I a C.* Seville: Fundación el Monte.

Chițescu, M. 1981. *Numismatic Aspects of the Dacian State.* Oxford: British Archaeological Reports International Series 112.

Crawford, M. H. 1969. *Roman Republican Coin Hoards*. London: Royal Numismatic Society, Special Publication No 4.

Crawford, M. H. 1974. *Roman Republican Coinage.* Cambridge: Cambridge University Press.

Crawford, M. H. 1985. *Coinage and Money under the Roman Republic.* London: Methuen.

Debernardi, P. 2012. La "riscoperta" del ripostiglio di Orzivecchi e le sue tipologie inedite.' *Panorama Numismatico* 9: 19–25.

Greenacre, M. J. 1984. *Theory and Applications of Correspondence Analysis.*

London: Academic Press.

Greenacre, M. J. 2007. *Correspondence Analysis in Practice*, second edition. Boca Raton, London and New York: Chapman and Hall.

Gruber, E. and K. Lockyear. 2015. From dBase III+ to the semantic web: twenty-five years of the *Coin Hoards of the Roman Republic* database *in* Arianna Traviglia (ed.) *Across Space and Time. Papers from the 41st Conference on Computer Applications and Quantitative Methods in Archaeology, Perth, 25–28th March 2013*, pp. 336–46. Amsterdam: Amsterdam University Press.

Hersh, C. A. 1977. Notes on the chronology and interpretation of the Roman Republican coinage. *Numismatic Chronicle* 137: 19–36.

Hersh, C. A. and A. Walker 1984. The Mesagne hoard. *American Numismatic Society Monographs and Notes* 29: 103–134.

Lockyear, K. 1989. *A Statistical Investigation of Roman Republican Coin Hoards.* Master's thesis, University of Southampton.

Lockyear, K. 1991. Simulating coin hoard formation. In *Computer Applications and Quantitative Methods in Archaeology 1990* edited by K. Lockyear and S. P. Q. Rahtz, 195–206. Oxford: British Archaeological Reports International Series 565.

Lockyear, K. 1993. Coin hoard formation revisited… In *Computer Applications and Quantitative Methods in Archaeology 1992 edited by* J. Andresen, T. Madsen and I. Scollar, 367–376. Aarhus: Aarhus University Press.

Lockyear, K. 1995. The supply of Roman Republican denarii to Romania. *Studii și Cercetări de Numismatică* 11: 85–102.

Lockyear, K. 1996a. Dmax based cluster analysis and the supply of coinage to Iron Age Dacia. In *Computer Applications and Quantitative Methods in Archaeology CAA95* edited by H. Kamermans and K. Fennema, pp. 165–178. Institute of Prehistory, University of Leiden, Leiden. Analecta Praehistorica Leidensia 28.

Lockyear, K. 1996b. *Multivariate Money. A statistical analysis of Roman Republican coin hoards with special reference to material from Romania.* Ph.D. thesis, Institute of Archaeology, University College London.

Lockyear, K. 1999a. Coins, copies and kernals — a note on the potential of Kernal Density Estimates. In *Computer Applications and Quantitative Methods in Archaeology 1997* edited by L. Dingwall, S. Exon, V. Gaffney, S. Laflin and M. van Leusen, pp. 85–90. Oxford: British Archaeological Reports International Series 750.

Lockyear, K. 1999b. Hoard structure and coin production in antiquity — an empirical investigation. *Numismatic Chronicle* 159: 215–243.

Lockyear, K. 2000. Site finds in Roman Britain: a comparison of techniques. *Oxford Journal of Archaeology* 19(4): 397–423.

Lockyear, K. 2007. *Patterns and Process in Late Roman Republican coin hoards 157–2 BC.* Oxford: British Archaeological Reports International Series 1733

Lockyear, K. 2008. Aspects of Roman Republican coins found in late Iron Age Dacia. In *Miscellanea numismatica Antiquitatis. In honorem septagenarii magistri Virgilii Mihailescu-Bîrliba oblata* edited by V. Spinei and L. Munteanu, Honoraria 4, 147–176. București: Editura

Academiei Române.

Lockyear, K. 2012. Dating coins, dating with coins. *Oxford Journal of Archaeology* 31(2): 191–211.

Lockyear, K. 2013. Applying bootstrapped correspondence analysis to archaeological data. *Journal of Archaeological Science* 40(12): 4744–4753.

Mattingly, H. B. 2004. *From Coins to History: Selected Numismatic Studies.* Ann Arbor: University of Michigan Press.

Orton, C. R. 1997. Testing significance or testing credulity? *Oxford Journal of Archaeology* 16(2): 219–225.

Pitts, M. and D. Perring 2006. The making of Britain's first urban landscapes: the case of late Iron Age and Roman Essex. *Britannia* 37: 189–212.

Popovitch, L. 2001. Les monnaies romaines. In *Alésia. Fouilles et recherches franco-allemandes sur les travaux militaires romains autour du Mont-Auxois (1991-1997)* edited by M. Reddé and S. Schnurbein, pp. 69– 95. Paris: Mémoire de l'Académie des Inscriptions et Belles Lettres, vol. XXII.

Reece, R. 1975. The Coins. In *Excavations at Portchester Castle* edited by B. Cunliffe, chapter 6, 188–197. London: Society of Antiquaries.

Reece, R. 1991. *Roman Coins from 140 sites in Britain*, provisional edition. Cotswold Studies IV. Cirencester: Cotswold Press.

Ringrose, T. J. 2012. Bootstrap confidence regions for correspondence analysis. *Journal of Statistical Computation and Simulation* 82(10): 1397– 1413.

Ryan, N. S. 1988. *Fourth Century Coin Finds in Roman Britain: a Computer*

Analysis. Oxford; British Archaeological Reports British Series No. 183.

Villaronga, L. 1993. *Tresors monetaris de la Peninsula Ibèrica anteriors a August: Repertori i Analisi*. Barcelona.

Walton, P. J. 2012. *Rethinking Roman Britain: Coinage and Archaeology*. Wetteren: Moneta.

Figure and Table list and captions

Table 1: Meaning of the various accuracy codes used in the CHRR database.

Code	meaning
1	exactly identified coin.
2	inexactly identified coin (‘as RRC…’).
3	copy of a specific coin (‘copy of RRC…’).
4	copy of a general type of coin of which the reference is an example (‘copy as RRC…’).
5	Almost exactly identified coin, e.g., either RRC 408/1a or 408/1b (‘as issue…’).
6	Coin in a Romanian hoard which is suspected to be a copy.
7	considered extraneous, usually by Crawford.
8	a general coin type, *e.g.*, miscellaneous Iberian *denarius*.
9	total in hoard unknown, i.e., only presence/absence of type.

Table 2: Hoards from 78–75 BC.

CHRR	name	RRCH	country	closing date	‘good’ total
ADM	Alba di Massa	289	Italy	77	82
ALX	Alexandria	295	Romania	77	32
BOM	Bompas	290	France	77	13
BRU	Brusc	284	France	77	15
COR	Cornetu (Căpreni)	296	Romania	75	128
INU	Inuri	—	Romania	77	37
KER	Kerassia	283	Greece	78	47
MNZ	Mainz	281	Germany	78	12
MAL	Maluenda	282	Spain	78	32
MBR	Mihai Bravu	—	Romania	75	56
ION	Montalbano Ionico	297	Italy	75	45
NER	Neresine, Lussino Island	—	Fmr Yugoslavia	78	42
NOY	Noyer	—	France	78	51
PSE	Puerto Serrano	—	Spain	77	28
RAN	Randazzo	287	Sicily	77	30
MAN	San Mango sul Calore	294	Italy	75	81
SDC	Santana da Carnota	—	Portugal	76	134
STE	Stejeriș	—	Romania	75	200
ZAT	Zătreni	—	Romania	75	41

Table 3: Hoards from 56–54 BC.

CHRR	name	RRCH	country	closing date	‘good’ total
ALD	Alésia, camp D	—	France	55	98
AMN	Amnaș	338	Romania	56	155
AN1	Ancona	344	Italy	55	42
BUZ	Buzău	346	Romania	54	48
CLN	Calinești	347	Romania	54	92
COM	Compito	345	Italy	55	929
DUN	Dunăreni	—	Romania	56	128
FND	Frauendorf (Axente Sever)	341	Romania	56	563
GRA	Grazzanise	349	Italy	54	257
ICN	Icland	—	Romania	56	33
KAR	Karavelovo	—	Bulgaria	54	35
MC1	Macedonia	—	Greece	54	91
SDS	Sălașul de Sus	348	Romania	54	103
SMC	Someșul Cald	321	Romania	56	115
SUS	Sustinenza	339	Italy	56	63
THS	Thessalonica	—	Greece	54	51

Table 4: Hoards compared to Alésia Camp D assemblage with a Dmax value less than 0.15.

CHRR	Name	RRCH	country	closing date	'good' total	Dmax
COM	Compito	345	Italy	55	929	0.08
VIS	Vișina	—	Romania	41	139	0.08
NAG	Nagykágya	411	Romania	42	131	0.08
PIE	Piedimonte d'Alife	406	Italy	42	191	0.09
PIA	Piatra Roșie	—	Romania	43	268	0.10
SIN	Sînvăsii	—	Romania	46	43	0.10
CAS	Casaleone	351	Italy	51	712	0.11
PRS	Poroschia	436	Romania	39	541	0.11
GRE	San Gregorio di Sassola	337	Italy	58	532	0.11
SMI	Sminja	395	Tunisia	45	912	0.12
SPR	Sprîncenata	—	Romania	46	110	0.12
BUZ	Buzău	346	Romania	54	48	0.12
PRE	Prejmer	412	Romania	42	150	0.12
ISS	Puy D'Issolu	—	France	46	39	0.12
JEG	Jegălia	—	Romania	43	453	0.13
JAE	Jaén	386	Spain	46	65	0.13
NB2	Nicolae Bălcescu II	—	Romania	42	43	0.13
ILI	Ilieni	—	Romania	46	109	0.13
BHR	'Bahrfeldt'	—	—	49	426	0.13
RAC	Răcătău de Jos II	—	Romania	39	53	0.13
TRN	'Transylvania'	369	Romania	47	36	0.13
TI2	Tîrnava	—	Romania	46	148	0.13
CNT	Conțești	—	Romania	15	141	0.13
FA1	Fărcașele	420	Romania	42	81	0.14
ISL	Islaz	—	Romania	42	124	0.14
HAG	Haggen	405	Switzerland	42	61	0.14
ODS	Orbeasca de Sus	—	Romania	48	139	0.14
STP	Stupini	—	Romania	41	227	0.14
GRJ	La Grajuela	—	Spain	51	523	0.14