REVUE BELGE

DE

NUMISMATIQUE

ET DE SIGILLOGRAPHIE

CLXVI – 2020

BELGISCH TIJDSCHRIFT

VOOR

NUMISMATIEK

EN ZEGELKUNDE

BRUXELLES – BRUSSEL

REVUE BELGE DE NUMISMATIQUE ET DE SIGILLOGRAPHIE

BELGISCH TIJDSCHRIFT VOOR NUMISMATIEK EN ZEGELKUNDE

TABLE DES MATIÈRES – INHOUDSTAFEL

COLLOQUIUM "THE ART OF MEDALS IN THE LOW COUNTRIES (16th-21st C.)" – BRUSSELS, 19/V/2019

MÉMOIRES – ARTIKELS

MÉLANGES – MENGELINGEN

COMPTES RENDUS – RECENSIES

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A METROLOGICAL SURVEY OF PTOLEMAIC BRONZE COINS – III. CYPRUS 1ST AND 2ND C. BC

***Abstract** – A quantitative analysis is presented of weights of Ptolemaic bronze coins of Cyprus from the second to first century BC, spanning the reigns of Ptolemy V and Cleopatra VII. The study relies on weights of over one thousand recorded specimens of more than 70 coin types. The data support comparisons of coin types and related series with one another and suggest broad weight and denomination relationships.*

Introduction

This study is preceded by other components of a broad metrological survey of Ptolemaic bronze coinage. The first publication (Wolf 2013) covers 3rd-c. BC Ptolemaic bronze coinage metrology of Egypt, Cyprus, and other provincial mints, for the reigns of Ptolemy I to IV. It exploits Olivier Picard & Thomas Faucher's model of Series 1-5 for 3rd-c. Alexandrian coinage [1]; said Series comprising several denominations related by control marks or other shared symbols, with simple weight and value ratios. I showed that 3rd-c. bronzes of several other mints, including Cyprus, parallel Alexandria's Series and weight standards, albeit sometimes with local designs and/or mintmarks. A second publication (Wolf 2016) on late Ptolemaic bronze coinage of Tyre includes metrology for those types [2]. The purpose of this third part is to report on the metrology of the later Ptolemaic bronze coinage of Cyprus.

Catharine Lorber (2001) realized that much of Cyprus's 2nd-c. bronze coinage is a continuation of the design, symbol, and denomination series relationships of the preceding decades. Quantitative support of that view is found in the results of this study. Alexandrian bronze coinage of the 2nd c., however, diverges into many unmarked types with new designs and peculiar weight ratios for which Series structures remain largely speculative. Many Ptolemaic mints produced somewhat similar types of coinage so they were analyzed together and comparatively in the first metrological survey. Alexandria's 2nd-c. bronze coinage is, however, so different from its contemporary Cypriot coinage that their metrological analyses are published separately. These new Cyprus metrology results also allow comparison with the contemporary Alexandria coinage (Wolf *forthcoming*).

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[1] Faucher & Lorber 2010, p. 22-59.

[2] Wolf 2016, p. 38-39.

Precedents

Catharine Lorber's discussion (Lorber 2001) of coins with the lotus flower mintmark is the most important review that includes later Cyprus types since Svoronos's (Svoronos 1904-1908), with updated regnal attributions and chronologies. She ties some related types together into denomination series and we include here coin types she groups as Series V, VI, and VII, as well as some additional types. Lorber's lotus-series nomenclature is easily confused with, and unrelated to, Series numbers in Picard & Faucher [3], Faucher & Lorber [4], and Wolf (2013) which also include some of the same Cyprus bronzes. This study therefore eschews the lotus-series nomenclature and simply groups related types that share symbols, control marks, and designs. Lorber sensibly corrects Svoronos's Ptolemy VI attributions of some Sv 1403 [5] and Sv 1404 to Ptolemy III for stylistic reasons, and all of Sv 1409-1414 to Ptolemy IV because they share control marks of other issues of Ptolemy IV from several mints. Those lotus-marked 3rd-c. types, not included in this study, are most recently analyzed elsewhere [6].

Data and Sources

This study is based on 1,114 specimens of 76 types. The weight data are from private, published, and museum collections, reference books, and some commercial and auction sales records. Care is taken to avoid duplications, e.g. coins listed in museum collection inventories and also in reference books. Museum and institutional collections include:

- American Numismatic Society database and Mantis online references
- Ashmolean Museum online references
- Bibliothèque nationale de France (BnF) database and online references
- British Museum (BM) Ptolemaic bronze coin database and online references
- Danish National Museum (*SNG Copenhagen*, Kromann & Morkholm 1978)
- Dutch National Collection inventory documents
- Fitzwilliam Museum online references
- Historical Museum of Frankfurt (Noeske 2000)
- Jon Hosking Collection (Pitchfork 2000)
- Köln Museum (Weiser 1995)

[3] Picard & Faucher 2012, p. 14-108.

[4] Faucher & Lorber 2010, p. 62.

[5] Most coin types mentioned in this publication are denoted with Svoronos catalogue numbers with Svoronos's name abbreviated as Sv, sometimes with 'a' appended indicating Svoronos's second volume catalog appendix. Some have numbers listed in Paphos II (Nicolaou 1990) and Curium (Cox 1959) excavation reports. A few have no catalog numbers and are known by detailed descriptions and illustrations in the plates.

[6] Lorber 2018, pp. 107, 134.

- Paphos II excavation reports (Nicolaou 1990)
- Curium excavation reports (Cox 1959).

Private collections data from A. Philippidis, C. Michael, G. Shiatis, and others.

Additional data are from books and catalogs including:

- J.N. Svoronos, Coinage of the Ptolemies (1904-1908)
- Joel Malter and Co. Auction of Ptolemaic Coins (23-24/II/1978)
- Auction catalogs and commercial sales records:
  - Classical Numismatic Group (CNG)
  - Forum Ancient Coins (FAC)
  - Harlan J. Berk Co.
  - Zurqieh Coins
- and some other internet auctions and commercial offerings.

The author gratefully thanks the collectors and coin dealers who shared specimen weight data and images that contribute to this study. Additional thanks are extended to Catharine Lorber for much thoughtful assistance and many helpful comments, Julien Olivier for the database of Ptolemaic bronze coins in the BnF, David Hendin and Elena Stolyarik of the ANS for help obtaining weight data and photographs of coins in the ANS collection, and Andrew Meadows for the British Museum database of Ptolemaic bronze coins.

Type Definitions, Coin Groupings, and Methodological Limitations

Most of the coin types are as described by Svoronos (1904-1908) and others are included that were not known to Svoronos. Several types are included that have not been previously described or illustrated in publication. Fifty-six coin types are illustrated in plates to help readers with type identifications, especially of the uncatalogued types not previously published. Some not illustrated are redundant (only different dates). Coins grouped together mostly follow the organization of Svoronos's catalog and also Lorber (2001), with ordinary relationships of common control marks or other shared properties.

Coins for which specific cataloguing or type identification is equivocal (i.e. a coin that might be designated 'cf' due to a specific identifier that is not clear such as a date, a control mark, or another symbol) are excluded in this study. Some of the coin types here are rare enough that equivocal identifications are not helpful and irrelevant coins were excluded by inspecting photographs. Therefore in some cases, as mentioned below, the coins and weight data are not all simply accepted as reported by sources. Lorber (2001) clearly shows that some different types are conflated as single Svoronos catalog numbers and in other cases two different catalog numbers are given to a single coin type.

The confusion of types catalogued as a single number is exemplified by Sv 1403, now recognized as two separate types issued by Ptolemy III [7] and Ptolemy VI or VIII. The assignment of multiple catalog numbers to a single type is exemplified by Sv 1405 and Sv 1637 [8]. Some specimens are included only subject to verification for these reasons and images available from various sources were invaluable in assuring coin type identifications. The Paphos II excavation specimens are excluded for some very small types (see Table 1) where photos show metal loss common for excavated coins, so they could bias calculated mean weights.

This study is about coin weights, not diameters nor thickness, for the same reasons discussed in Wolf 2013 and *forthcoming*. The only unambiguous metrological data for these coin types are weights.

Analytic methods, statistical comparisons, and the limitations of numerical accuracy are those of my previous Ptolemaic bronze metrology studies. The statistical analyses include Mean, standard deviation, and percentiles, which are straightforward calculations. Comparative tests (Kolmogorov-Smirnov, Student's t, and analysis of variance, histograms, and Gaussian Kernel estimate graphs) can show whether some weight distributions of populations differ significantly. Regression analyses help model denominations of some related series. Many of the automated online calculation and analytical tools are those used previously as well. Internet resources and other computer programs for statistical tests and graphing are listed in Appendix 1.

Summaries of the analyses for the 76 coin types are presented in Tables 1, 2, and 3. Some coin types are grouped according to shared control marks or other symbols (e.g. the dated series of Ptolemy VIII including Sv 1621-1632), and some coins of like sizes and/or other shared properties are combined for aggregate population statistics. The tables are organized similarly with a row for each individual coin type and its statistics in columns which are:

1. Descriptor – A short descriptive label for each type – design, symbol, date, or other visual identifier. Their relevance and meanings are self-evident.
2. Type/Ref – Svoronos catalog number, with a few types not catalogued by Svoronos listed by their catalog numbers in Cox (1959) and Nicolaou's Paphos II excavations report (1990) or in a few cases with an 'x' if no catalog reference is available.
3. Den – Putative denomination in chalkoi (1 drachm = 48 chalkoi) or according to module (A-D)
4. SP – Total number of specimens with known weights available for this study

[7] Lorber 2018, p. 107.

[8] Lorber 2001, p. 48.

5. OL – Statistical outliers excluded from subsequent metrology calculations. They are reported in a dedicated column though they are too few to have made any significant differences in the results. Their identification by Tukey's criterion (using automated online methods) is discussed in Wolf 2013 [9]. Weight outliers are few in number for most of the types and their exclusion from mean weight and other calculations is consistent with previous methods but may be of little quantitative significance here.
6. Mean – Mean weight is the simple average weight of the included specimens.
7. SD – Standard deviation is also the simple calculation that indicates how widely weights spread above and below the mean value, as the Ptolemaic bronze weights always vary and it is clear they were not minted to specific individual weights (*al pezzo*). See the discussion of the latter also in Wolf 2013 [10].
8. Gauss – This is an estimate of the degree of similarity of the coin weight distribution to one with the Gaussian (bell shape) curve and proportions. This figure is generated by an online tool for Kolmogorov-Smirnov tests and percentile graphs [11] that calculates Kolmogorov-Smirnov group comparison statistics and also identifies statistical outliers (Tukey criterion) best excluded from the weight distributions statistics.
9. GK Pk – The Gaussian Kernel Peak is the weight at which the Gaussian Kernel density estimate graph reaches a maximum, an alternative mode value (of a perfect continuous Gaussian distribution estimated from the actual discrete weight distribution) that can be compared with the mean weight. The figure is generated by an online tool for producing Gaussian Kernel density estimate graphs. [12]

Most of the coin types here are unequivocally identifiable by designs or symbols and distinct weight distributions and do not raise the difficulties of some of the 2nd-c. Alexandria issues [13]. Gaussian kernel estimate graphs are especially helpful for some similar types that are not as easily distinguished and which have overlapping weight distributions. Gaussian kernel estimates here also provide modes of hypothetically continuous weight distributions, rather than from histograms, and occasionally expose distributions with multiple modes and the inflection points between overlapping weight distributions.

[9] Wolf 2013, p. 53.

[10] *Ibid.*, p. 84-86.

[11] http://www.physics.csbsju.edu/cgi-bin/stats/KS-test.n.plot

[12] https://www.wessa.net/rwasp_density.wasp

[13] See Wolf *forthcoming*.

A. Aphrodite Obverse – Sv 1160-1162 – Table 1 – Pl. 1·1-1·3

The dating of these coins is uncertain and they may have been produced for a long time, perhaps starting with Ptolemy IV [14] but possibly continuing for many decades (Lorber 2001). One type has two cornucopiae on the reverse (Sv 1160) and another, otherwise similar, has only one cornucopia (Sv 1161). The two types are metrologically indistinguishable (mean weights of 1.57 and 1.62 g, respectively). The mean weight of 100 specimens, combined, is 1.58 g.

Sv 1162 is a third Aphrodite portrait type with a small bird, possibly a dove rather than the usual Ptolemaic eagle, on the reverse. The mean weight of 15 specimens is 1.18 g, about ⅔ that of the coins with cornucopia reverses.

B. Thunderbolt/Eagle – Sv 1246 – Table 1 – Pl. 1·4

This coin type is very small, rare, and has an unusual design without a portrait. It is a single very small denomination, Svoronos 1246. The obverse design element is a thunderbolt and the reverse has a small bird that resembles that of Sv 1162, with the usual Ptolemaic inscription. Typical specimens of this type are thick beveled flans and small, about 10 mm. Mean weight of 15 specimens (excluding three weight outliers) is only 0.86 g. The metrology is clear, but the denomination is uncertain. A nearly 2:1 weight ratio of Aphrodite/cornucopia types to Thunderbolt type might imply a comparable value ratio, perhaps dichalkon and chalkous.

C. Corinthian Helmet Symbol – Sv 1634 and 1635– Table 1 – Pl. 1·5-1·6

Two coin types (Sv 1634 and 1635) have a large and recognizable crested Corinthian helmet symbol to the left of the single standing eagle on their reverses. That field is the location of a mintmark on many Ptolemaic coins (club, harpa, trident, tripod and others on coins from various other mints) it is not known if the helmet is a mintmark. These types are clearly of two different sizes, both of which share a distinctive style that is similar to the following pair (Sv 1636 and Sv 1637). While the large helmet symbol is seen only on these two types, Lorber [15] discusses their association with Cyprus and a die link with the Lotus and Scepter types (below). Mean weights of the helmet types are 40.7 and 20.5 g, suggesting a monetary value relationship of 2:1.

D. Lotus and Scepter – Sv 1636 and 1637 – Table 1 – Pl. 1·7-1·8

Sv 1636 and 1637 are similar in sizes to the preceding pair. These have a reverse with a single standing eagle with closed wings, facing left, lotus flower mark at left, and a scepter crossing the eagle with its tip to the right of the eagle's

[14] Svoronos 1904-1908, p. 188.

[15] Lorber 2001, p. 51.

shoulder. Lorber [16] discusses them in some detail, noting Svoronos's conflation of Sv 1405 with Sv 1636, and presents a stylistic rationale for assigning them (and the helmet types above) to the reign of Ptolemy V. Care was taken to inspect images to differentiate specimens of Sv 1637 from Sv 1406, which also has a scepter on the reverse but the latter has eagles rendered in a distinctly different style. The mean weights of Sv 1636 and 1637 are 39.7 g and 22.0 g, respectively.

Relationships of Corinthian Helmet Series (Sv 1634 and 1635) and Lotus and Scepter Series (Sv 1636 and 1637)

A Kolmogorov-Smirnov comparison (KS test) shows the weight distributions of Sv 1634 and Sv 1636, the larger of each of these pairs, are indistinguishable ($p > 0.4$) and they clearly are lighter than Series 4-like tetrobols issued on Cyprus by Ptolemy IV [17] and Ptolemy VI-VIII [18]. These two groups with similar sizes may represent an episodic break in Series 4-like coinages and Lorber [19] suggests that Sv 1636 and Sv 1637 are issues no later than the time of Ptolemy V. In subsequent discussions [20] Lorber notes these Series also share a die link suggesting they are nearly contemporary.

The weight statistics of both groups are similar to one another and Lorber [21] suggests the heavier coins' weights are comparable to the novel weight of some Ptolemy V coins of Alexandria with similarly rendered eagles (Sv 1423). Lorber [22] links the Cyprus types Lotus-with-Scepter and Helmet to Ptolemy V.

Faucher & Lorber [23] also posit that Zeus Ammon coins with two standing eagles on the reverse (Sv 1423, with a mean weight of 39.2 g [24]) define a transition of Alexandria's bronze coinage from Series 5 to a new Series 6 during the reign of Ptolemy V. I analyzed the weight properties of Sv 1423 for a separate forthcoming publication, finding an overall mean weight of 39.2 g (112 specimens). They are lighter than Series 3-5 tetrobols (~45.6 g), heavier than Series 5 hemidrachms (~34.2 g), yet similar to the weights of Cypriot Sv 1634

[16] *Ibid.*, p. 45-46.

[17] Lorber 2018, p. 135. Svoronos 1411, 1413, 1414 are Series 4 tetrobols which have a mean weight of 45.8 g (Wolf 2013, Table 4).

[18] Lorber 2001, p. 47.

[19] *Ibid.*, p. 45.

[20] *Ibid.*, p. 51.

[21] *Ibid.*, p. 46.

[22] *Ibid.*, p. 47-51.

[23] Faucher & Lorber 2010, p. 38.

[24] The Zeus Ammon coins with two eagles on the reverse depict three variations of Zeus Ammon. Two of them, unlike any other Ptolemaic bronze coins, have unusually prominent Ammon horns. All three variations have eagles with partly bare 'bristle-feather' legs that resemble preceding types. Wolf (*forthcoming*) has shown their weight distributions are statistically alike, and their overall mean weight is 39.2 g.

and Sv 1636. Analysis of Variance (ANOVA) comparison of Sv 1423 (112 specimens), Sv 1634 (11 specimens), and Sv 1636 (16 specimens) indicates they are all alike ($p > 0.2$). Novel ~40 g weights and other factors hint that all could be contemporary. A combination of stylistic, die link, and quantitative consistencies are compatible with a hypothesis that Cyprus briefly shared Alexandria's evolution of bronze coinage with novel weights. The comparative metrology sheds some new light on these coinage relationships.

E. EYΛ Series 1-6, Sv 1395-1402 – Table 1 – Pl. 2·1-2·6

This group comprises eight Svoronos catalog numbers, 1395-1402, and one additional uncatalogued type (see below). All of these have Zeus Ammon on the obverse, a single closed-wing eagle on the reverse with EYΛ control letters in the space between thickly-feathered eagle legs. Lorber's assertion [25] that Sv 1395, 1399, and 1400 lack the lotus blossom is erroneous [26]. Svoronos's catalog numbers are incomplete so their statistics are in Table 1 as six different weight groups, EYΛ 1 – EYΛ 6.

Sv 1395 (EYΛ 1, Octobol)

Three specimens are known and the mean weight of 88.8 g indicates this type is a 2nd-c. Cypriot parallel to 3rd-c. BC Series 4 octobols of Alexandria and Cyprus [27]. The results for this rare type are summarized in Table 1, with the descriptive entry EYΛ 1.

Uncatalogued Type (EYΛ 2, Tetrobol)

Two specimens are known with mean weight 45.1 g, which are 2nd-c. Cypriot parallels Series 4 tetrobols, a half denomination of Sv 1395 of similar design. These are obviously rare and were not perceived by Svoronos. One specimen is illustrated by Lorber [28], and another appeared in a 2017 auction.

Sv 1396 (EYΛ 3)

The 38 specimens of Sv 1396 have mean weight of 22.8 g. The scepter device on the reverse makes this type easily recognizable and its mean weight is consistent with the diobol of a Series 4 denomination model. Two specimens are unusually heavy and excluded from the weight statistics here. At 30.99 and 31.21 g, they are 6 to 10 g heavier than other Sv 1396, which range from 20.36 to 25.10 g. The two anomalously heavy coins could represent a variety of Sv 1396 not previously recognized.

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[25] Lorber 2001, p. 46.

[26] Svoronos's description of the sole catalogued, but not illustrated, specimen of Sv 1395 mentions the lotus flower and photos of some Svoronos catalog specimens of Sv 1399 and 1400 show lotus flowers.

[27] Wolf 2013, Table 3.

[28] Lorber 2001, Plate 5·11, later sold at auction in 2008.

Sv 1397, 1398, 1399, 1400, and 1401 (EYΛ 4 and EYΛ 5)

Svoronos describes Sv 1397 and 1398 as measuring 25 mm in diameter; a Seleukid anchor countermark distinguishing Sv 1398. Svoronos's lists weights for both types of a total of only five specimens [29], with a mean value of 15.94 g.

Svoronos describes Sv 1399 and 1400 as being nearly the same as Sv 1397 and 1398 [30]. The weights given for Sv 1399-1400, however, are lower than for Sv 1397-1398: 10 to about 13 g (vs. ~15-17 g for the preceding two types). The mean of eight data in Svoronos's catalog is 11.8 g. There are too few specimens for analytic comparisons but it is clear that Svoronos segregated relatively heavy (Sv 1397 and 1398) and lighter (Sv 1399 and 1400) coins of nearly the same size. Some coins of each weight group show the anchor countermark, so four types are the result. The punched countermarks do not add or remove metal and so do not affect analysis of the weights.

Svoronos describes Sv 1401 as measuring 22 mm but otherwise the same as the preceding four types, sometimes with the anchor countermark. Svoronos's only listed weights of Sv 1401 (10.35 and 10.65 g), however, overlap with the range of Sv 1399 and 1400.

The ease of confusing them makes cataloguing of all five of these types (Sv 1397, 1398, 1399, 1400, 1401) haphazard and inconsistent in various publications and even Svoronos's catalog. [31] The most useful metrological analysis is an examination of the weight distribution of all five types together. They are easily distinguished from the larger Sv 1396 by its scepter device and from the obviously smaller Sv 1402 (only 18 mm, a single 8.2 g weight specimen in Svoronos).

Weights of 87 specimens easily identifiable as among Sv 1397-1401 are used here. Graph 1 is the histogram of the combined coins, with bin width about 0.25 g. Two distributions are evident and are more easily seen with the Gaussian kernel estimate plot in Graph 2 [32], which shows the two groups hinted by

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[29] 15.45 and 14.98 g (Sv 1397), 15.00, 17.36, 16.91 g (Sv 1398).

[30] Svoronos 1904-1908, p. 229. The only difference between Svoronos's descriptions (p. 229) of Sv 1397 and Sv 1399 is that Sv 1397 mentions a dotted border on the reverse. Lorber (2001, p. 46) mistakenly asserts that Sv 1395, 1399, and 1400 have the EYΛ control letters but lack the lotus flower mark. Svoronos (p. 229) does note that Sv 1399α lacks a lotus flower but others, such as Sv 1399ιη and Sv 1399ιθ, illustrated in Macdonald 1905 (pl. LXXXIII·16), do have one. The lotus flower is also obvious on specimens of Sv 1395 auctioned in recent years. Its idiosyncratic absence on a few specimens is not a uniform or defining feature of any of these types.

[31] CNG Eauction 390, lot 228 (22.5 mm, 11.81 g, without countermark) catalogued as Sv 1398; Forum Ancient Coins SH58536 (22.5 mm, 10.74 g, with countermark) also catalogued as Sv 1398; British Museum CGR64759, 10.32 g, has no countermark but is listed as Sv 1400 by Svoronos. These examples defy consistent criteria for assessing catalog numbers.

[32] Gaussian Kernel Estimate graphs are helpful adjunct histograms, illustrating the weight distribution data as continuous curves that simplify their visual assessment. Appendix 1 has more information about Gaussian Kernel Estimates for graphical interpretation of weight distributions.

Svoronos's stated weights of 1397-1398 and 1399-1401 as two modal peaks. One is near 12 g and another near 16 g. They are ~11.8 and ~15.6 g, found by simply drawing vertical lines on an enlarged copy of the graph. The inflection minimum between them is about 14.4 g. Though the weight groups overlap (see above), we can separate the 87 coins into two groups defined by the inflection.

Of the 87 coins, 67 are lighter than 14.4 g (~9.6 to 14.2 g), with mean and modal peak near 11.9 g. The heavier group of 20 coins (excluding one heavy outlier) are 14.6 to 17.4 g, with mean weight and modal peak near 15.6 g. Any single specimen weighing near 14 g might belong to either the heavier group or the lighter group. There is no obvious way to better distinguish the weight groups. Countermarking is metrologically irrelevant and Graph 2 illustrates that, considered *en masse*, the five types are actually two weight populations with means that differ by about 4 g. Table 1 has entries for the two weight groups, EYΛ 4 and EYΛ 5, irrespective of the five catalog numbers.

Sv 1402 (EYΛ 6)

There are only three weight data for Sv 1402, with mean value of 7.12 g.

Alexandria's mid-3rd-c. Series 4 bronze coinage, led by massive bronze octobols of ~91.5 g [33] was mostly produced during the reign of Ptolemy III [34]. A Cypriot analog was introduced at about the same time with a lotus flower mintmark on the reverse [35]. Additional Series 4-like coinage were minted on Cyprus, with ocotobol denominations and lotus flower mintmark, apparently after Alexandria's Series 4 ceased. Two such groups have control marks used by Ptolemy IV [36] and the EYΛ Series and its apparent successor, the Lotus-Only Series extend the production of Series 4-like denomination sets well into the 2nd c. on Cyprus.

The EYΛ coins are similar to Series 4 coins (of both Alexandria and Cyprus) of the preceding century, reprising the weight standard of about 1.44 g per chalkous). Graph 3 is a regression plot of 135 specimens with putative denominations of the six EYΛ coin sizes:

- EYΛ 1 – 64 chalkoi (octobol)
- EYΛ 2 – 32 chalkoi (tetrobol)
- EYΛ 3 – 16 chalkoi (diobol)
- EYΛ 4 – 12 chalkoi (trihemiobol)
- EYΛ 5 – 8 chalkoi (obol)
- EYΛ 6 – 4 chalkoi (hemiobol)

[33] Wolf 2013, Table 3, p. 103-104.

[34] Lorber 2018, p. 85-95.

[35] *Ibid.*, p. 107, CPE B458.

[36] *Ibid.*, p. 134.

The plot shows a weight standard (slope) of about 1.38 (g per chalkous). The zero-value intercept is small (0.71 g) and the correlation coefficient of the least-squares data fit for this linear regression is 0.99.

F. Lotus-Only Series 1-5, Svoronos 1403-1408 – Table 1 – Pl. 2·7-2·11

These five types closely resemble the previous types (Sv 1395-1402) with similar lotus flower mintmark but absent EYΛ control letters. Specimens of Sv 1403 (8) and 1404 (7) included here are only those verified from photographs to exclude examples of somewhat similar 3rd-c. types, CPE B438 and B439. Lorber [37] shows that Sv 1405 is a mistaken duplication by Svoronos. Sv 1406 coins are potentially confused with Sv 1637, both with scepters on the reverse, but they can be visually distinguished and 12 specimens of Sv 1406 included here are also verified from photos.

Sv 1403 – Lotus 1

Eight specimens have a mean weight of 90.8 g and clearly represent an octobol of the same weight standard as the 3rd-c. BC Series 3-5. These are analogs of the EYΛ octobol type, Sv 1395.

Sv 1404 – Lotus 2

Seven specimens have mean weight 45.1 g, the tetrobol among this group, analogous to the uncatalogued EYΛ tetrobol.

Sv 1406 – Lotus 3 (with scepter)

Twelve of these have a mean weight of 21.7 g, the diobol among this group, congruent to the EYΛ series diobol, with scepter, Sv 1396.

The three sizes are obvious elements of a weight and value structure associated with 3rd-c. Series 4 with octobol, tetrobol, diobol, etc. They are congruent to size and weight analogs of the EYΛ group, of similar metrological structure, with additional quantitative comparison below (see Discussion).

Sv 1407 – Lotus 4

This smaller type may be congruent and monetarily equivalent to EYΛ series type Sv 1402. Only two specimens are available here, with a mean weight of 5.61 g. Little more can be said about this denomination with such a small population. Three unverified coins from Paphos II report are over 3.5 g, which might be specimens of Sv 1407, are not included here.

[37] Lorber 2001, p. 48.

Sv 1407 – Lotus 5

This smallest Lotus Only type has no obvious equivalent size in the EYΛ series but they are nevertheless included with them here. Twenty specimens have a mean weight of 2.25 g. Specimens from the Paphos II excavations report (Nicolaou 1990) are excluded for consistency, as only a small minority are recognizably intact in the report's photographs whereas the majority are either fragments or unverifiable.

The Lotus-Only Series (50 coins in all) also resembles a Series 4 structure. Graph 4 is a linear regression plot with denominations like those used above:

- Lotus 1 – 64 chalkoi (octobol)
- Lotus 2 – 32 chalkoi (tetrobol)
- Lotus 3 – 16 chalkoi (diobol)
- Lotus 4 – 4 chalkoi (hemiobol)
- Lotus 5 – 2 chalkoi (dichalkon)

The regression line fits with a slope (weight standard) of 1.429 g per chalkous and a small intercept (zero-value weight) of –0.68 g. The correlation coefficient for the least-squares regression line is >0.99.

The Lotus-Only series is congruent and parallel to the EYΛ series, and both of them are likely extensions of the 3rd-c. Cypriot Series 4 coinage recognized by Lorber [38]. The largest three denominations of the two series are very similar. There are too few specimens for statistical comparisons but their respective mean weights are so similar that equivalent denomination structures are immediately obvious to the most casual observer. Graphs 3 and 4 expose the similarities. They are also quite similar to the regression plot of Series 4 coinage published in the earlier metrology study [39], which has a slope of about 1.44.

G. Dated Lotus Series – Svoronos 1621-1632 – Table 1 – Pl. 3·1-3·2

These twelve coin types bear explicit Greek dates spanning 144 to 129 BC, during most of the sole reign of Ptolemy VIII. The shared design is Zeus Ammon on the obverse and a single closed-wing eagle facing left on the reverse with a lotus flower to the left and the date above it. Two are slightly different. Sv 1624 (year 28, 142 BC) has a petasos symbol (with loose hanging straps) to the right of the eagle on the reverse. Another of that year is Sv 1625 with a star symbol to the right of the eagle. The metrology of all twelve of these is unremarkable, with mean weights of the individual types varying from about 8 to about 11 g. Each catalogued type has a row entry in Table 1, in Svoronos's numerical (and chronological) sequence. The descriptive headings in the left column are the

[38] Lorber 2001, p. 43.

[39] Wolf 2013, p. 70, Graph 13.

Greek dates. Some types are represented by as few as a single specimen, but seven types by 10 or more. None of the mean weights (in some cases just individual specimens) raise metrological questions. Only one specimen recorded by Svoronos has an anomalously high (outlier) weight of 16.52 g. The overall mean weight of the other 135 specimens of all twelve types (combined) is 9.37 g.

The series of 12 catalogued types spans about 15 years apparently as Cyprus's sole bronze coinage, a single unknown denomination. The mean weight of this group, about 9.4 g, is as enigmatic as that they seem to be only one denomination. There is no obvious link between their metrology or design with any of the preceding (EYΛ or Lotus-Only) denominations. Their isolation and scarcity could indicate a near cessation of bronze coin production or usage during a period of about 15 years.

H. Symbols – Svoronos 1694-1703 and Types Not In Svoronos – Table 2 – Pl. 3·3-3·13 and Pl. 4·1-4·4

These are 19 identifiable types with Zeus Ammon on the obverse, one or two closed-wing eagles on the reverse and one of eleven symbols in the left field of the reverse. These symbols are thunderbolt, bird (possibly a small eagle), petasos, cornucopia, owl, winged insect (bee or fly), wreath, aphlaston, caduceus, palm branch, and trident that are not seen on other groups of Ptolemaic bronzes minted on Cyprus. They often appear hastily or poorly manufactured and lack the small cavities that evidence mechanical smoothing of the flans prior to striking. Some have much wider weight ranges than seen with other, more carefully made, types. The entire group of 18 types counts only 181 coins of known weight, most with only one to ten specimens per type. The descriptive heading column in Table 2 names symbols. Their mean weights suggest possibly four weight groups which have no obvious connections to sizes and weights of the preceding EYΛ, Lotus-only, or date series. There are too few coins to unequivocally establish the exact division of the two largest weight groups (here Sizes C and D). The size definitions may be improved and relationships to other coinages exposed with additional coin weight data in the future. The two larger sizes have some coins with weight ranges that overlap, but the largest (Size D) includes only the obviously heaviest types that include specimens over 30 g. Sizes A and B are easily separable and Size C are the remainder, mostly types with weight ranges between 10 and 20 g. Table 2 also has a summary the four denominations, proposed as follows, of the symbol types on individual lines with their own statistics (Symbol Types D, etc.).

Size D – 53 specimens

Thirty-six specimens of Sv 1694 obviously exemplify the largest denomination. They range from 17 to 35 g, with a mean of 25.22 g, and the Gaussian

kernel estimate graph is broad and flat between 20 and 28 g, with a modal peak at 27.4 g. Sixteen specimens of Sv 1695 (about 13 to 37 g, mean of 23.93 g), and one large specimen with the palm branch symbol (36.86 g) are the other components of this largest apparent denomination. Taken together, the 53 specimens have a mean weight of 25.22 g and a standard deviation of 5.78 g. They are also up to 40 mm in diameter, but they are thinner and lighter than earlier Ptolemaic bronzes that large. They give the impression of a significant visual presence, a large denomination, but of about half the metal of earlier types of similar size.

Size B – 87 specimens

Sixty-three specimens of Sv 1698, with a mean weight of 5.98 g, are the dominant components of a denomination of 'symbol' coins of about 6-7 g. Seventeen specimens of the type known from Curium excavations (Curium 119) [40], with one eagle and a petasos in the left field, have a mean weight of 6.98 g. In addition, there are five specimens of Sv 1702 (wreath symbol) with a mean weight of 6.98 g. These weights also overlap over much of their ranges and therefore group together. Two Sv 1703 also appear to belong with this denomination group, but are too few for meaningful statistics. The 87 specimens have a mean weight of 6.25 g.

Size A – 13 specimens

The smallest coins, only 13 specimens, are easily segregated and have a mean weight of 1.82 g. The best-represented are the eight of the type with a petasos symbol to the left of the eagle, known from the Paphos II excavations [41] (nos. II·381 and II·382) and two private collections, but not catalogued by Svoronos. Those have a mean weight of 1.81 g. Another type with caduceus symbol [42] (Paphos II·395) is known from only three specimens. One small coin has a palm branch (1.50 g) and another has a star at left (Paphos II·396, 1.68 g) [43].

Size C – 34 specimens

Thirty-four coins remain, comprising Size C. There are seven types: diademed petasos (Sv 1696), cornucopia (Sv 1697), owl (Sv 1699), insect (Sv 1700), wreath (Sv 1701), and uncatalogued types with caduceus (one specimen), palm branch (eight specimens), and trident (one specimen). The mean weight, excluding a single outlier, is 15.52 g.

[40] Cox 1959, p. 106.

[41] Nicolaou 1990, p. 49 and pl. XII·381(1781) and XII·382(1828).

[42] *Ibid.*, p. 50 and pl. XIII·395(1992).

[43] *Ibid.*, p. 50 and pl. XIII·396(4395).

About half of the 19 types discussed here were not known to Svoronos. Those include Curium 119 [44] and some reported by Nicolaou [45] among coins excavated on Cyprus as well as museum specimens, commercial auction sales, and private collections. It is not certain whether these 19 symbol types comprise a single coherent group, but they are easiest to discuss together as their fabric and shared design elements distinguish them from the other groups. They plausibly segregate into four distinguishable sizes or denominations (A, B, C, and D, in order of increasing mean weight). Several of the symbols appear on more than one of the sizes, adding to the impression these are a coinage series.

The determination of sizes may improve, but overlapping weight ranges seem likely in any arrangement. In a weight model of value, the Size D coins obviously have higher value than Size A, but the value relation between Sizes D and C is not as obvious in light of their overlapping weight ranges. Some symbols (petasos, cornucopia, palm branch) are on several sizes, so it is unlikely that the symbols are value marks.

The results presented above show there are perhaps four sizes or denominations. The petasos, caduceus, palm branch, wreath, and cornucopia are each seen on more than one size, so the symbols are not value marks. Multiple sizes linked by the same symbol are analyzed as potential Series structures here. The smallest two sizes, with 1.82 and 6.25 g as mean weights, are obvious from the weight data. The largest size (D, see above) likely comprises only three types which include specimens over 30 g. Sv 1694 (thunderbolt symbol) is the largest contribution to Size D and the weight ranges are unusual, with the heaviest about twice the weight of the lightest:

Size D Types		Weight Range (in g)
Sv 1694	36 specimens	17.00 – 35.48
Sv 1695	16 specimens	13.42 – 37.43
Palm Branch	1 specimen	36.76

The heaviest putative Size D specimen has nearly three times the weight of the lightest, and these weight ranges overlap those of types contributing to Size C. There must be uncertainty about one-specimen types that could be either Size C and Size D. I cannot be certain if all the heavier coins among these symbol types belong to two different weight groups (C and D) or only a single one. The hypothesis that there are two large sizes is plausible as the consequent weight distributions for four denominations are individually unimodal and uncomplicated. The paucity of data for many of these types is an obstacle to

[44] Cox 1959, p. 106 and pl. iv.

[45] For example, Nicolaou 1990, p. 48-49, lists five specimens (nos. 376-380) of the type designated here as Curium 119.

understanding them better, so coins that come to light in the future may support the metrology-inspired hypotheses here or lead to better ones.

There is no obvious monetary meaning of this unusual group of coins that appears to be multiple denominations of substantially overlapping weight ranges. Graph 5 is a regression fit for the 187 symbol type coins, of a value model for the sizes of 1, 4, 12, and 16 units (possibly chalkoi). The slope is 1.52 g per unit, zero value weight is small (– 0.05 g), and the correlation coefficient is 0.91. Other possible value models (e.g. 1, 4, 10, 16) might even better fit the weight data for these coins. Even if these coins' large weight ranges are due to careless and imprecise manufacturing, the mean weights of type and size groups may nevertheless be proportional to value. The imprecision and unusual overlapping weight ranges may be part and parcel of other changes in coin manufacture exemplified by these types.

I. No Symbols – Sv 1712-1715/1716 – Table 2 – Pl. 4·5-4·8

This design, style, and fabric are similar to the preceding group, but these have no symbol in the left field on the reverse. These are Svoronos 1712, 1713 and 1714, 1715, and 1716, with one or two eagles on the reverse. Their weight information is given in Table 2 (No Symbols, One Eagle Plain and Two Eagle Plain). I cannot tell apart coins identified as Sv 1715 and 1716, so they are combined here. There are three clear weight ranges. Sv 1712 is alone the heaviest, with a mean weight of 14.25 g. Sv 1713 and 1714 have slightly different designs but essentially identical mean weights of 7.49 and 7.47 g, respectively. Sv 1715-1716 together have mean weight 1.91 g. Additional quantitative analysis of their relations to Sizes A, B, C, and D (above) is discussed below.

These types without symbols on the reverse parallel the putative denominations (A, B, and C) of the preceding Symbol Types and they may well belong together. Their sizes and fabric are also consistent with that interpretation. The smallest, Sv 1715 and 1716, are difficult enough to distinguish that it may be unwise to assign two catalog numbers.

The general resemblance of these types to the symbol types (above), however, suggests these could be their 'no-symbol' analogs. The three mean weights similar to Sizes A, B, and C suggest statistical comparisons. Kolmogorov-Smirnov comparisons of the three potentially equivalent groups, however, yield varying results:

Symbol (#sp)	Wt	No Symbol (#sp)		Wt (in g)	KS Test P Value
Size C (33)	15.52	1712	(16)	14.25	>0.27 – similar
Size B (87)	6.25	1713-14	(22)	7.48	0.01 – not similar
Size A (13)	1.82	1715-16	(28)	1.91	>0.44 – similar

Two of the sizes share weight distributions but the the middle sizes appear to differ. The difference might indicate different denominations (values) or just

poorly controlled coin weights, but we are unable to conclude that all three sizes are similar.

Graph 6 shows all 253 coins of both families with denominations used for Graph 5, but accounting for the difference noted above by modeling Sv 1713-1714 as six units. The combined regression plot has a slope of about 1.48, a very small zero-value weight of – 0.09 g, and a correlation coefficient of about 0.92. We can model these coins consistent with weight standards (value proportional to weight), but the analyses remain incomplete due to the extreme scarcity of some types and the unusually wide and overlapping weight ranges. Understanding of these and the Symbol types may benefit from other metrological models and additional study.

J. Letter and Star/Letter – Sv 1242a, 1706-1711 – Tables 2-3 – Pl. 4·9-4·12 and Pl. 5·1-5·2

Twelve coin types have reverse designs with a star, a star above a single letter, or only a single letter in the reverse left field. There are two sizes: small, with a single eagle on the reverse, and large, with two eagles. Only 18 coins of all eight two-eagle types are available for this study, their rarity today perhaps being due to a very limited production. The plate images include several unique specimens of types not previously illustrated in publication (see Key to Plates, below). Statistics are shown for individual types in Table 2 (One Eagle|∗|Letter) and Table 3 (Two Eagles|∗|Letter), with summary statistics for each of the two sizes. The collected 49 specimens of smaller one-eagle coins have a mean weight of 7.23 g. The 18 larger two-eagle coins have a mean weight of 15.11 g.

Two weight groups are obvious with a ratio of approximately 2:1. These denominations are also marked by one eagle (smaller denomination) and two eagles (larger denomination). The calculated mean weights of the two denominations are similar to two of the weights of some other types (see Conclusions, below).

K. Big Symbol Types – Sv 1813 and 1814 – Table 3 – Pl. 5·6-5·7

Two types have unusually large symbols in the left field of the reverse. Sv 1813 has a very large aphlaston symbol which occupies nearly the entire field, larger than on any other coin type. Sv 1814 has a cornucopia symbol filling much of the field area and also obviously larger than on other Ptolemaic bronze coin types. Table 3 has the weight information for 60 and 24 specimens of the two types. Mean weights (7.49 and 6.80 g, respectively) are similar and a KS comparison shows the weight distributions are alike (60 and 24 specimens, $p > 0.14$), from which I infer they are a single denomination. The 84 combined specimens have a mean weight of 7.29 g.

L. Isis Headdress Types – Sv 1842 and 1843 – Table 3 – Pl. 5·8-5·9

Two coin types have a headdress of Isis in the left field of the reverse, one with a complex monogram beneath (Sv 1842) and one without the monogram (Sv 1843). Analyses of these fairly common types were made on over 60 specimens of each, and their mean weights are 5.49 and 5.97 g, respectively, as shown in Table 3. The KS test shows their distributions are alike ($p = 0.06$).

M. Cleopatra VII with Baby – Sv 1874 – Table 3 – Pl. 5·10

Svoronos 1874 depicts Cleopatra VII carrying a baby on the obverse with a large double cornucopia on the reverse and complex monogram in the right field. Nineteen specimens available here have a mean weight of 15.94 g.

N. Zeus Ammon, Eagle with Transverse Palm Branch – Sv 1875 – Table 3 – Pl. 5·11

Svoronos 1875 has Zeus Ammon on the obverse and one closed-wing eagle on the reverse with a palm branch traversing the eagle diagonally. Thirty-nine specimens have a mean weight of 7.03 g.

O. Zeus Ammon, Two Eagles with Scepter – Sv 1876 – Table 3 – Pl. 5·12

Svoronos 1876 has Zeus Ammon on the obverse, with a small star near the forehead of Zeus, and two closed-wing eagles on the reverse traversed diagonally by a scepter. Svoronos does not mention the star symbol near the forehead of Zeus, clearly visible on all four specimens available for this study. The mean weight of the four specimens is 12.72 g.

P. Zeus Ammon and Cornucopia – Paphos II·383 – Table 3 – Pl. 5·3

This type is known from the Paphos II publication [46] of Cypriot excavations that yielded three specimens of a type not known to Svoronos and not recorded in reference books and most major collections. The reverse has a single filleted cornucopia that is reminiscent of the Aphrodite types Sv 1160 and 1161. Four additional specimens contribute to the statistics here that are shown in Table 3 with the heading: Paphos II·383. Their mean weight is 2.06 g, and this type might well represent the same small denomination as others with similar size and weight discussed earlier.

Q. Reverse with Lotus and Star at Right – Table 3 – Pl. 5·4

Two specimens are known with a mean weight of 1.98 g. This coin type was not known to Svoronos and has no catalog number from reference books or published collections.

[46] Nicolaou 1990, p. 49 and pl. XIII·383(1633), XIII·384(1999) and XIII·385(3761).

R. Reverse with Transverse Scepter – Table 3 – Pl. 5·5

Five specimens have a mean weight of 2.30 g. This coin type was also not known to Svoronos and has no catalog number from reference books or published collections. It may be related to Sv 1876.

Conclusions

A metrological evolution of the later Ptolemaic bronze coinage of Cyprus is evident from the structure developed by Catharine Lorber's (2001) study of the types with lotus flower mint mark, progressing through coinages with different symbols and sizes and which have a less coherent structure.

1. The ЄΥΛ and Lotus Only types are images of Series 4 of the preceding century, adhering to its sizes and weights, led by octobols (64 chalkoi) with a mean weight of about 91.2 g.
2. The Helmet and Lotus-Scepter types are distinct in appearance and markings, about 40 g and 20 g. The pairs are die-linked to one another and have similar weights, which might well derive from or mirror Alexandrian issues with similar 40 g weight.
3. The Dated-Lotus types are distinct from all the others and easily recognized as such. Their metrology is uncomplicated but a denomination cannot be inferred from their apparently atomic quality with a mean weight of 9.37 g. They are likely an obol denomination based on preceding types.
4. The remaining coinages are unknown denominations but they segregate into five groups, ordered below according to increasing weight. These are all types likely produced after those that parallel the Alexandrian weights like Series 4 (ЄΥΛ, Lotus Only, etc.). There are obvious separations between these groups (2–5 g, 10–14 g, etc.).

	Weight (in g)	Specimens
Mean Weight <1 g		
Thunderbolt | Eagle	0.86	15
Mean Weight 1–2.5 g		
Aphrodite | Eagle	1.18	15
Aphrodite | Cornucopia	1.58	97
Symbol Types Size A	1.82	13
No Symbol Size A	1.91	28
Paphos II·383	2.06	7
Lotus and Star at Right	1.98	2
Eagle with Scepter	2.30	5

Mean Weight 5.5-8 g		
Isis Headdress	5.67	121
Symbol Types Size B	6.25	87
* Palm Branch Reverse	7.03	39
* Big Symbols	7.29	84
* One Eagle|∗|Letter	7.23	49
* No Symbol Size B	7.48	22
Mean Weight 14-16 g		
** Scepter Reverse	14.14	6
** No Symbol Two Eagle Size C	14.25	16
** Symbols Types Size C	15.52	33
** Two Eagles|∗|Letter	15.11	18
** Cleopatra & Baby	15.94	19
Mean Weight > 20 g		
Symbol Types Size D	25.22	53

The five types (marked ** above) with mean weights in the the 14-16 g range are indeed alike (ANOVA, quantities as shown above, $p = 0.4$, Box Plot in Graph 7). Likewise, the four types (marked * above) with mean weights from 7-8 g are also alike (ANOVA, quantities as shown, $p > 0.6$, Box Plot in Graph 8). The ANOVA tests are imperfect applied to weight distributions that are not exactly Gaussian shapes, but there is nothing surprising about them as the mean weights of the different groups are close to one another and weight ranges are similar. These later Cyprus bronze coins may well share a chronologically continuous denomination structure with relative values in the ratio 2:1.

These types with statistically linked weight ranges might be traditional Ptolemaic bronze coin denominations (obol and diobol or hemidrachm and drachm, etc.) valued in proportion to ~7.5 and ~15 g weights. They evidence less precise fidelity to a weight standard than the preceding types analogous to Series 4. These later denominations are unknown.

Variable production quality and large weight ranges are evident for individual types, especially in the series of Symbol Types. They are unlike many preceding coinages that are better made with identifiable weight standards. Most of these possibly different denominations also share a single Zeus Ammon obverse design over many sizes and weights. These properties may speak to a value model for late Cyprus coins without strict weight standards, governed by easily perceived differences of physical size. Metrological and other properties of these later coins may be due to crude minting technology producing a few denominations of (possibly fiat) money disconnected from weight standards, few enough to be distinguished visually. The later types with statistically equal weights (e.g. five types of Size C), for example, may be of

equal value or just a happenstance of re-use of existing flan models for casting molds.

The likely chronology of later Cyprus bronze coinage progresses from well-understood structures of related types with parallels to the preceding century and coins of other mints, on to later types with less obvious metrological structure. The relationships between sizes, weights, and values of the last Cyprus Ptolemaic bronze coins will benefit from additional study of more specimens, especially of rare types, as well as analysis of contemporary history, politics, and monetary economy among the community of classics scholars.

Table 1 – Late Cyprus Ptolemaic Bronze Coins – 31 Types – 509 Specimens

Descriptor	Type/Ref	Den	SP	OL	Mean	SD	Gauss	GK Pk
Aphrodite | 2 cor	1160*	A	80	2	1.57	0.33	0.06	1.43
Aphrodite | 1 cor	1161*	A	20	1	1.62	0.28	0.83	1.50
Total	*1160+1161**	*A*	*100*	*3*	*1.58*	*0.32*	*0.04*	*1.44*
Aphrodite | eagle	1162*	A	15	0	1.18	0.31	0.54	0.95
Th-bolt | eagle	1246*	?	18	3	0.86	0.13	0.58	0.91
Corinth. helmet	1634	32	11	0	40.7	6.24	0.79	36.7
Corinth. helmet	1635	16	21	0	20.5	2.31	0.89	21.7
Lotus + scepter	1636	32	16	0	39.7	4.90	0.73	37.3
Lotus + scepter	1637	16	7		22.0	2.26		
ΕΥΛ 1	1395	64	3		88.8			
ΕΥΛ 2	x	32	2		45.1			
ΕΥΛ 3	1396	16	40	2	22.8	1.22	0.59	23.0
ΕΥΛ 4	1397-1401	12	20	1	15.8	0.75	0.61	15.8
ΕΥΛ 5	1397-1401	8	67	0	11.9	1.01	0.33	11.9
ΕΥΛ 6	1402	4	3		7.12			
Lotus 1	1403	64	8		90.8	4.98		
Lotus 2	1404	32	7		45.1	2.54		
Lotus 3	1406	16	13	0	21.9	2.21	0.75	20.7
Lotus 4	1407	4	2		5.61			
Lotus 5	1408*	2	20	0	2.25	0.41	0.88	2.15
LKϚ	1621	8	17	0	9.47	0.80	0.43	9.93
LKZ	1622	8	29	1	8.63	1.37	0.94	8.60
LKH	1623	8	12	0	9.43	1.39	0.50	8.99
LKH Petasos	1624	8	11	0	10.4	1.54	0.67	10.5
LKH Star	1625	8	1	0	9.27			
Total LKH	*1623-1625*	*8*	*24*		*9.88*	*1.49*	*0.41*	*9.17*
LKΘ	1626	8	3		11.0			
LΛ	1627	8	4		9.89			
LΛΓ	1628	8	19	1	9.10	1.02	0.82	9.97
LΛΔ	1629	8	31	0	9.58	1.74	0.51	8.31
LΛE	1630	8	3		9.31			
LΛϚ	1631	8	1		11.3			
LMA	1632	8	5		7.96	0.80		
Total	*1621-1632*	*8*	*136*	*1*	*9.37*	*1.50*	*0.23*	*9.79*

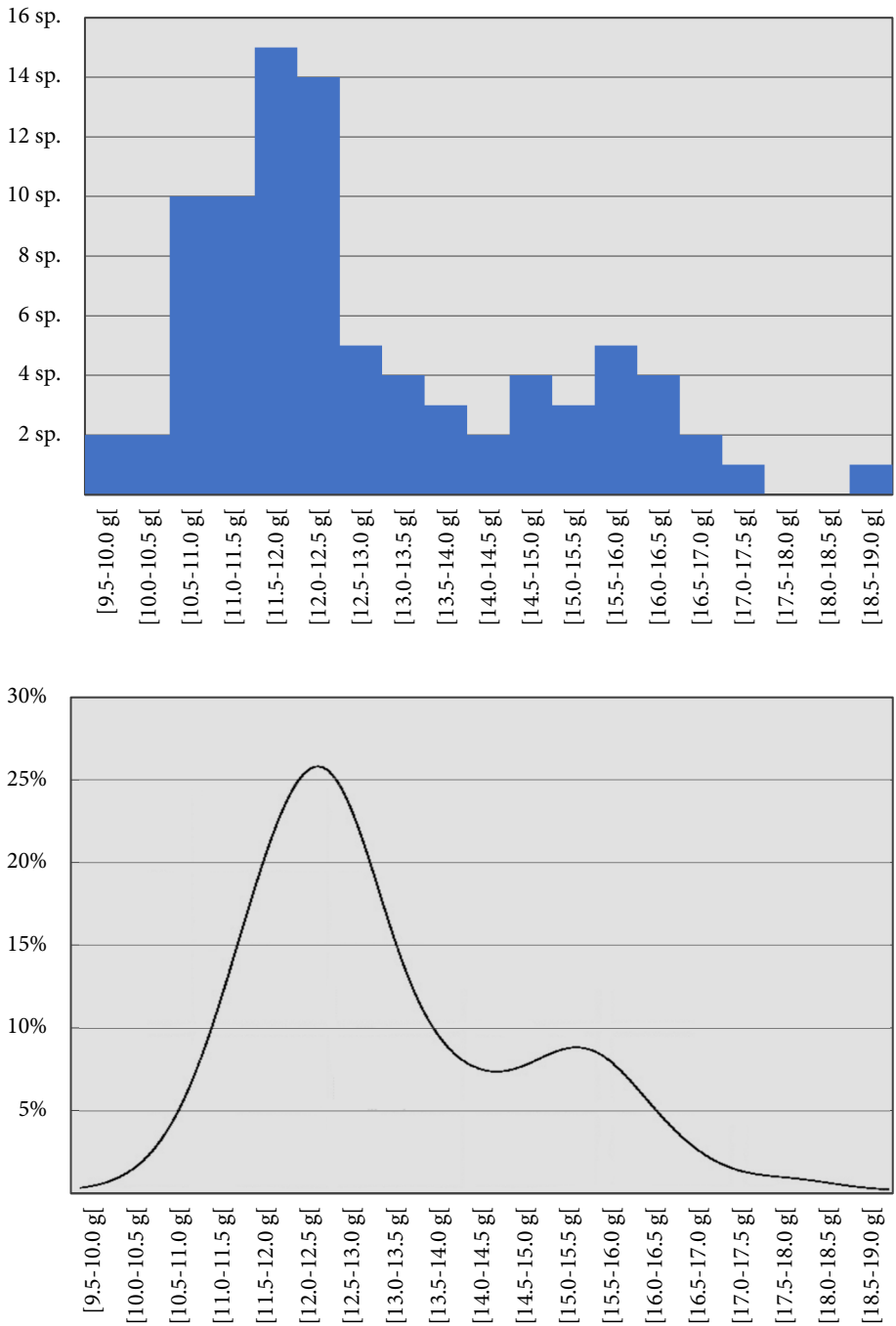
* *Specimens from Paphos II excavations are excluded from these samples*

Table 2 – Late Cyprus Ptolemaic Bronze Coins – 27 Types – 302 Specimens

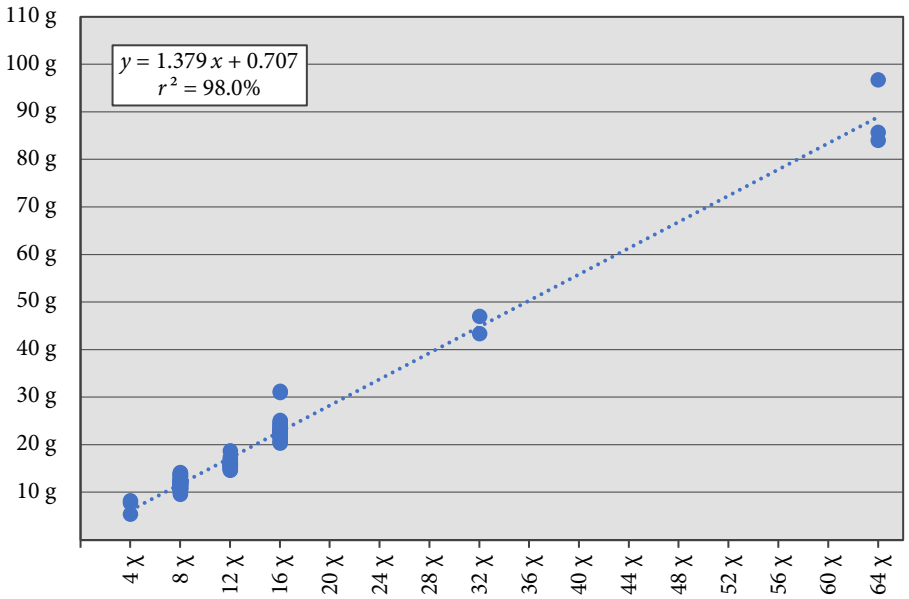
Descriptor	Type/Ref	Den	SP	OL	Mean	SD	Gauss	GK Pk
Thunderbolt	1694	D	36	0	25.47	4.87	0.91	26.6
Small eagle	1695	D	16	0	23.93	7.04	0.87	27.5
Petasos C	1696	C	6		20.41	4.81		
Petasos B	Curium 119	B	17	0	6.98	1.00		7.20
Petasos A	Paphos II·381	A	8		1.81	0.56		
Cornucopia C	1697	C	5		13.45	3.78		
Cornucopia B	1698	B	63	0	5.98	1.17	0.64	6.44
Owl	1699	C	1		17.70			
Bee or fly	1700	C	2		20.68			
Wreath C	1701	C	10		15.35	1.97	0.69	14.8
Wreath B	1702	B	5		6.98	1.82		
Small aphlaston	1703	B	2		6.75			
Caduceus C	x	C	1		18.22			
Caduceus A	Paphos II·395	A	3		1.98			
Palm branch D	x	D	1		36.76			
Palm branch C	x	C	8		12.91	1.73		
Palm branch A	x	A	1		1.50			
Star at right	Paphos II·396	A	1		1.68			
Trident	x	C	1		16.16			
Total Symbol Types Size D			***53***	***0***	***25.22***	***5.78***	***0.99***	***27.4***
Total Symbol Types Size C			***34***	***1***	***15.52***	***3.41***	***0.73***	***15.3***
Total Symbol Types Size B			***87***	***0***	***6.25***	***1.24***	***0.77***	***6.58***
Total Symbol Types Size A			***13***	***0***	***1.82***	***0.47***	***0.99***	***1.94***
Two eagles | –	1712	C	16	0	14.25	3.17	0.52	12.4
Two eagles | –	1713	B'	18	0	7.49	1.68	0.23	6.47
One eagle | –	1714	B'	4		7.47			
One eagle | –	1715+1716	A	28	0	1.91	0.53	0.66	2.18
One eagle | ∗	1242a	B'	8		7.81	1.04		
One eagle | ∗ | Δ	1706	B'	13	1	7.31	0.97	0.52	7.22
One eagle | ∗ | T	1711	B'	28	0	7.14	1.37	0.49	7.39
Total One eagle | ∗			***49***	***0***	***7.23***	***1.29***	***0.22***	***7.36***

Table 3 – Late Cyprus Ptolemaic Bronze Coins – 18 Types – 303 Specimens

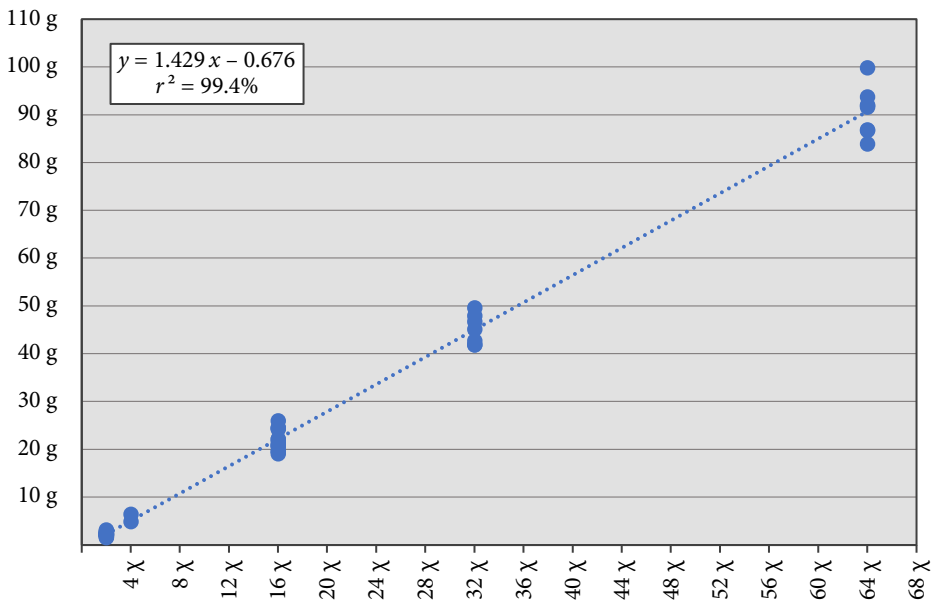
Descriptor	Type/Ref	Den	SP	OL	Mean	SD	Gauss	GK Pk
Two eagles | ∗ | H	1707	C	3		15.36			
Two eagles | ∗ | Λ	x	C	1		10.59			
Two eagles | ∗ | Σ	x	C	1		13.70			
Two eagles | K	1708	C	6		15.22	3.10		
Two eagles | Λ	1709	C	2		18.92			
Two eagles | M	1710	C	2		16.00			
Two eagles | T	x	C	2		14.83			
Two eagles | ∗	x	C	1		14.27			
Total	***1707-10+∀x***	***C***	***18***	***0***	***15.11***	***2.74***	***0.47***	***13.7***
Zeus | 1 cornuc	Paphos II·383	A	7		2.06	0.53		
Lotus & star rt	x	A	2		1.98			
1 eagle & scepter	x	A	5		2.30	0.24		
Big aphlaston	1813	B'	60	0	7.49	1.26	0.82	6.80
Big cornucopia	1814	B'	24	0	6.80	1.22	0.50	5.82
Total	***1813+1814***	***B'***	***84***	***0***	***7.29***	***1.28***	***0.85***	***6.80***
Isis hddrs | mgm	1842	B	62	0	5.49	1.06	0.61	5.61
Isis headdress | –	1843	B	61	0	5.97	1.51	0.52	5.17
Total	***1842+1843***	***B***	***123***	***2***	***5.67***	***1.24***	***0.31***	***5.06***
Cleopatra & baby	1874	C	19	0	15.94	2.00	0.70	16.0
Palm transverse	1875	B'	39	0	7.03	1.57	0.19	7.48
Scepter reverse	1876	C	6		14.14	2.40		



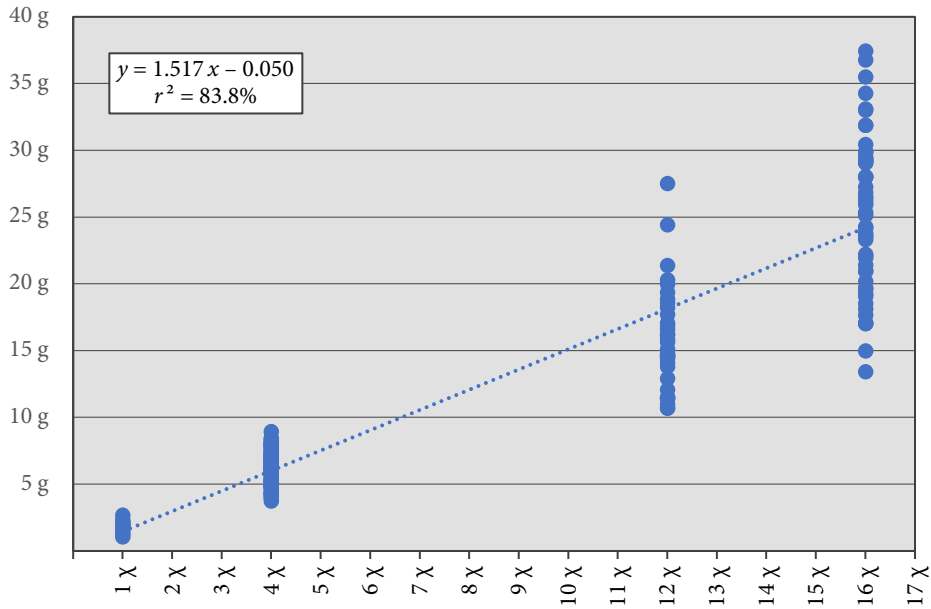
Graphs 1-2 – Histogram (above) and Gaussian kernel density diagram (below) of Sv 1397-1401 (total: 87 specimens). The data point to a mixture of two distributions with mode peaks at c.11.8 and c.15.6 g



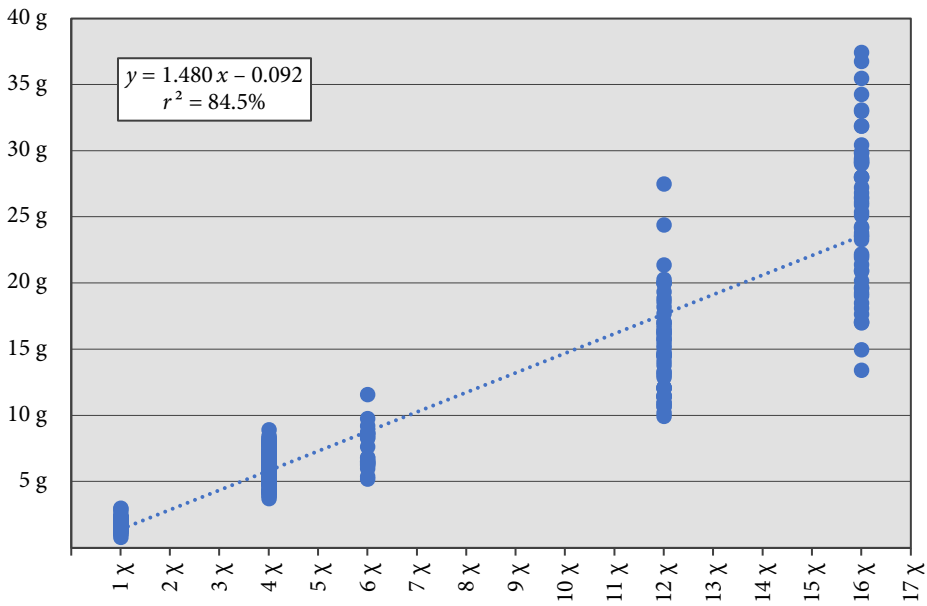
Graph 3 – Best fitting straight line for dataset 'EYΛ Series 4' = Sv 1395-1402 (total: 135 specimens – χ = chalkoi); 95% confidence intervals: slope: 1.345 to 1.413 g/χ; y-intercept: + 0.185 to + 1.229 g



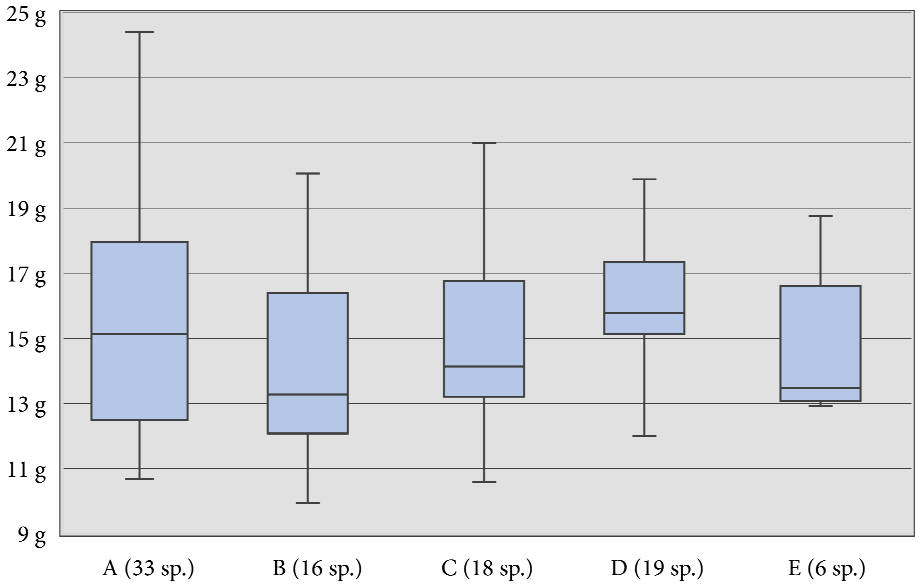
Graph 4 – Best fitting straight line for dataset 'Lotus only Series 4' = Sv 1403-1408 (total: 50 specimens – χ = chalkoi); 95% confidence intervals: slope: 1.396 to 1.461 g/χ; y-intercept: – 1.631 to + 0.280 g



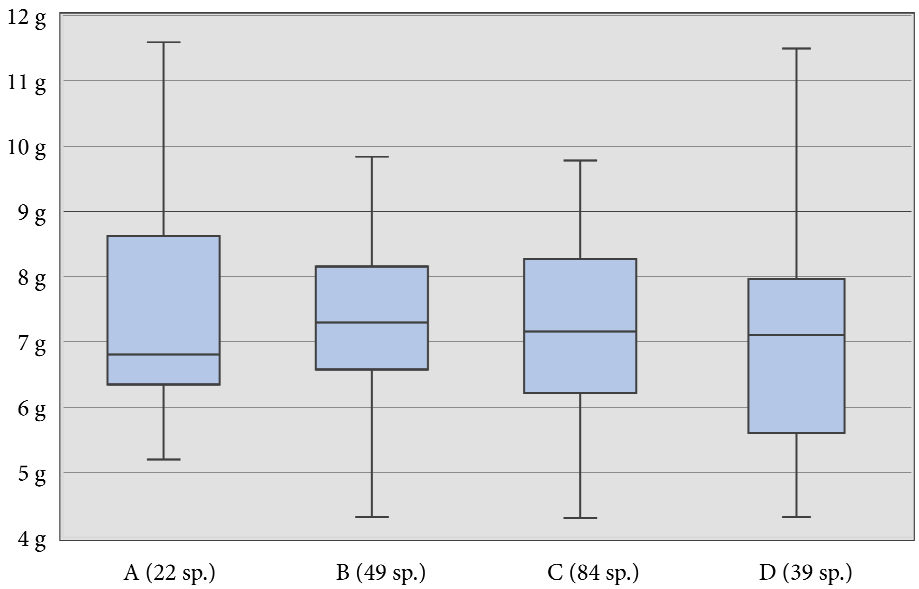
Graph 5 – Best fitting straight line for dataset 'Types with symbol' = Sv 1694-1703 et al. (total: 187 specimens – χ = chalkoi); 95% confidence intervals: slope: 1.420 to 1.614 g/χ; y-intercept: – 1.406 to + 0.947 g



Graph 6 – Best fitting straight line for dataset 'Types with and without symbols' = Sv 1694-1716 (total: 253 specimens – χ = chalkoi); 95% confidence intervals: slope: 1.401 to 1.558 g/χ; y-intercept: – 0.845 to + 0.550 g



Graph 7 – ANOVA Box plot for five size C groups (mean weights of 14 to 16 g) showing minimum, maximum and 1st, 2nd and 3rd quartiles; A = Types with symbol – B = Sv 1712 – C = Types with ✻ and letter – D = Sv 1874 – E = Sv 1876



Graph 8 – ANOVA Box plot for four size B groups (mean weights of 7 to 8 g) showing minimum, maximum and 1st, 2nd and 3rd quartiles; A = Sv 1713-1714 – B = Types with ✻ and letter – C = Sv 1813-1814 – D = Sv 1875

Key to Plates

Coins are shown approximately true size, except some very small types (marked with * below) that are at scale 200%.

Plate 1

1*	Svoronos 1160	CNG Auction 70 (21/IX/2005), lot 426
2*	Svoronos 1161	CNG Auction 132 (1/II/2006), lot 80
3*	Svoronos 1162	CNG Auction 132 (1/II/2006), lot 81
4*	Svoronos 1246	PtolemAE Collection E582
5	Svoronos 1634	PtolemAE Collection E690
6	Svoronos 1635	PtolemAE Collection E713
7	Svoronos 1636	PtolemAE Collection F002
8	Svoronos 1637	PtolemAE Collection F071

Plate 2

1	Svoronos 1395	CNG Auction 88 (14/IX/2011), lot 552 (sickle countermark)
2	Svoronos xxxx	CNG Auction 185 (2/IV/2008), lot 133 (Π-T countermark)
3	Svoronos 1396	PtolemAE Collection F083
4	Svoronos 1398	PtolemAE Collection E195 (anchor countermark, ΠΤΟΛΕ-ΜΑΙΟΥ inscription effaced)
5	Svoronos 1401	PtolemAE Collection E743 – Not obviously distinguishable from Svoronos 1397
6	Svoronos 1402	PtolemAE Collection E738
7	Svoronos 1403	PtolemAE Collection E086
8	Svoronos 1404	ANS 1951.116.354
9	Svoronos 1406	PtolemAE Collection E198
10	Svoronos 1407	Courtesy G. Boersema VCoins Store SKU 11524
11	Svoronos 1408	PtolemAE Collection F032

Plate 3

1	Svoronos 1624	PtolemAE Collection F005
2	Svoronos 1628	PtolemAE Collection E901
3	Svoronos 1694	PtolemAE Collection E990
4	Svoronos 1695	CNG Auction 348 (8/IV/2015), lot 108
5	Svoronos 1696	PtolemAE Collection E445
6	Curium 119	PtolemAE Collection E638
7	Paphos II 381	PtolemAE Collection E994
8	Svoronos 1697	PtolemAE Collection E767
9	Svoronos 1698	PtolemAE Collection E784
10	Svoronos 1700	C. Michael Collection
11	Svoronos 1701	G. Shiatis Collection
12	Svoronos 1702	C. Michael Collection
13	Svoronos 1703	PtolemAE Collection E979

Plate 4

1	Uncatalogued	PtolemAE Collection E450 (Caduceus Symbol, Size C)
2*	Paphos II 395	C. Michael Collection (Caduceus Symbol, Size A)
3	Uncatalogued	PtolemAE Collection E576 (Palm Branch Symbol, Size C)
4	Uncatalogued	G. Shiatis Collection (Trident Symbol, Size C)
5	Svoronos 1712	PtolemAE Collection E359
6	Svoronos 1713	PtolemAE Collection E761
7	Svoronos 1714	G. Shiatis Collection
8*	Svoronos 1715-6	CNG Auction 76 (12/IX/2007), lot 919
9	Svoronos 1242a	PtolemAE Collection F072
10	Svoronos 1706	PtolemAE Collection E797
11	Svoronos 1711	PtolemAE Collection E707
12	Uncatalogued	C. Michael Collection (Star above Σ)

Plate 5

1	Svoronos 1708	G. Shiatis Collection
2	Uncatalogued	C. Michael Collection (Letter Τ)
3*	Paphos II 383	PtolemAE Collection E816
4*	Uncatalogued	CNG E Auction 398 (14/VI/2017), lot 346
5*	Uncatalogued	PtolemAE Collection E424 (Scepter across eagle)
6	Svoronos 1813	Courtesy Harlan J. Berk
7	Svoronos 1814	PtolemAE Collection E801
8	Svoronos 1842	PtolemAE Collection E539
9	Svoronos 1843	C. Michael Collection
10	Svoronos 1874	CNG Inventory 770608
11	Svoronos 1875	Courtesy Ancient Imports
12	Svoronos 1876	PtolemAE Collection F078

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Appendix 1 – Statistics, Computational, and Image Resources

A. Graphing and Statistical Calculation Tools

1. Statistical comparison of weight distributions (Kolmogorov-Smirnov, Student's t-Test, ANOVA, etc.) as well as basic distribution calculations such as mean, standard deviation, and estimation of outliers by Tukey's method.

   http://www.physics.csbsju.edu/stats

   This tool also generates KS comparison graphs and box plots for ANOVA, t-Test, and more.

2. Gaussian Kernel Density Estimation Graphs and Peak Values

   https://www.wessa.net/rwasp_density.wasp

   Gaussian Kernel Density Estimation Graphs (GK graphs) and histograms are alternatives presentations of weight distributions. GK graphs are smoothed ideal Gaussian continuous curves and can provide a clearer view of the distribution's properties (its shape) than the histogram can. Histograms always have bin widths and the view of the histogram differs for different bin width values. It is not quite certain just which bin width gives the least biased or fairest view of the discrete weight distribution.

   The GK graph tool has an analogous parameter, the bandwidth, that plays a role similar to bin width for the histograms. The systems for histograms and GK graphs used here allow manual selection of these parameters and the GK graph system can automatically select an optimized bandwidth. The GK graphs here use the built-in optimal bandwidth which is recorded along with the Gaussian modal peak reported by the online system.

   The GK Graph 2 is a smooth continuous display of the same weight distribution seen in the histogram of Graph 1. The GK graph may make some weight distributions easier to interpret than a discrete histogram with its typical coarse appearance. The distribution's modal peaks and inflection point are easier to see in Graph 2 than in Graph 1.

B. Ptolemaic Coin Data and Images Online

1. Cambridge University – Fitzwilliam Museum (UK)

https://webapps.fitzmuseum.cam.ac.uk/explorer/

2. Yale University (USA)

https://artgallery.yale.edu/collection/search/ptolemaic

3. American Numismatic Society (USA)

http://numismatics.org/search/department/Greek

4. British Museum (UK)

https://www.britishmuseum.org/research/collection_online/search.aspx

5. Princeton University (USA)

http://libweb5.princeton.edu/numismatics/db.aspx

6. Bibliothèque nationale (France)

https://gallica.bnf.fr/services/engine/search/sru?operation=searchRetrieve&version=1.2&query=%28colnum%20adj%20%22MonnGre%22%29%20and%20%28subgallica%20all%20%22%C3%89gypte%22%29&filter=#resultat-id-11

7. Staatliche Museen zu Berlin (Germany)

http://www.smb-digital.de/eMuseumPlus?service=direct/1/ResultLightboxView/preselectFilterSection.$FilterGroupControl.$MpDirectLink&sp=10&sp=Scollection&sp=SfilterDefinition&sp=0&sp=0&sp=1&sp=Slightbox_3x4&sp=0&sp=Sdetail&sp=0&sp=F&sp=S10036&sp=S5

8. Harvard University (USA)

https://www.harvardartmuseums.org/collections

1
(*scale 200%*)

2
(*scale 200%*)

3
(*scale 200%*)

4
(*scale 200%*)

5

6

7

8

PLATE 1

1

11

2

10

3

9

4

8

5

7

6

PLATE 2

1

2

3

4

5

6

7

8

9

10

11

12

13

PLATE 3

1

2*
(*scale 200%*)

3

4

5

6

7

8*

9

10

11

12

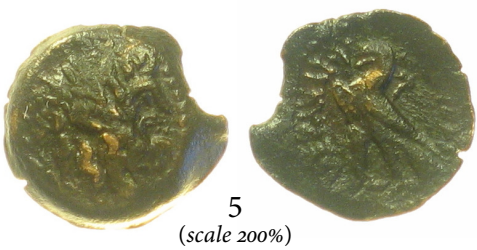
PLATE 4

1

2

3
(*scale 200%*)

4
(*scale 200%*)



5
(*scale 200%*)

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PLATE 5