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CONTENTS

BOARD OF EDITORS

Playing Sudoku on the Verso of the 'Muziris Papyrus' : Pepper, Malabathron and Tortoise Shell in the Cargo of the *Hermapollon**

FEDERICO DE ROMANIS

To Romila Thapar

Among the ships crossing the Arabian Sea in the first centuries of the Christian era, those that sailed from Egypt to the Malabar Coast were distinctive because of their size. The author of the *Periplus Maris Erythraei* describes these vessels as 'very big' (μέγιστα)[1], a characterization he uses only one other time in this text, in reference to the Indian ships that sailed from the Coromandel coast to the Ganges or to the Malay peninsula[2]. According to him, the rationale behind such uncommon dimensions was to accommodate the exceptional quantities of pepper and malabathron being transported to Egypt: "Very big ships sail to these [sc. Limyrike's] emporia on account of the weight and the volume of the pepper and malabathron".

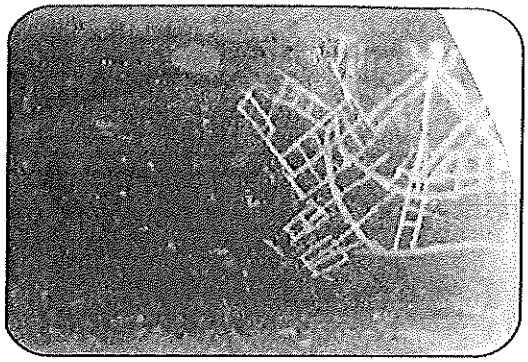

Fig. 1. Rouletted Pot Sherd with Graffito from Alagankulam. Picture from Sridhar 2005

The exceptional size of these vessels, combined with their exotic provenance or destination, elicited the enthusiastic admiration of the Indian and the Mediterranean worlds alike. Their images were reproduced in the ports of the Indian Ocean[3]. Tamil poets of the Sangam age praised them as the perfect and wonderful constructions of the *Yavaṉar*[4]. At the beginning of the III cent. AD, when the golden age of this pattern of trade was coming to an end, Philostratus still evoked them as an allegory of a universe wisely ruled by a supreme God and other subordinate deities:

"[...] we will [...] take a ship, such as the Egyptians construct for our seas and launch for the exchange of Egyptian goods against Indian wares. For there is an ancient law in regard to the Red

Sea, which the king Erythras laid down, when he held sway over that sea, to the effect that the Egyptians should not enter it with a vessel of war, and indeed should employ only a single merchant ship. This regulation obliged the Egyptians to contrive a ship equivalent to several at once of those which other races have; and they ribbed the sides of this ship with bolts such as hold a ship together, and they raised its bulwarks and its mast to a great height, and they constructed several compartments, such as are built upon the timber balks which run athwart a ship, and they set several pilots in this boat and subordinated them to the oldest and wisest of their number, to conduct the voyage; and there were several officers on the prow and excellent and handy sailors to man the sails; and in the crew of this ship there was a detachment of armed men, for it is necessary to equip the ship and protect it against the savages of the Gulf that live on the right hand as you enter it, in case they should ever attack and plunder it on the high seas"[5] (transl. Conybeare 1912: 311).

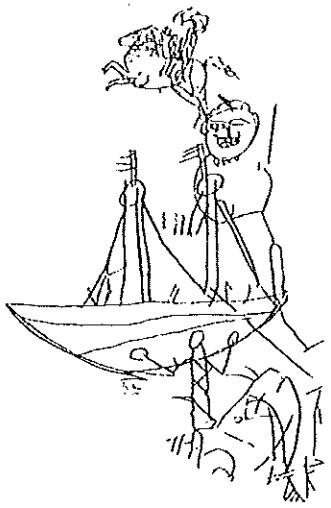

Fig. 2. Graffito from Khor Rori. Picture from Avanzini 2008

The export of Malabar pepper, either westwards or eastwards, required ships considered remarkable for their size in later historical periods as well. Those ranked by Marco Polo as the 'first among the wonders of India' are said to have been capable of a load of 5,000 or even 6,000 *esportes/sporte* of pepper[6]. More modest but still remarkable (1,000/1,200 *bahâr*[7]) were the cargo of the ships that exported pepper from Calicut to Aden and Mecca before the arrival of the Portuguese[8]. Safety and economy, conflicting motivations, made the Portuguese disagree about the best tonnage for their trade with India[9]. In 1570 a decree by D. Sebastian, king of Portugal, prescribed that the ships of the *Carreira da Índia* should have a tonnage between 300 and 450 *tonéis*[10]. Both before and after that date, however,

the *naus* crossing the oceans between Portugal and India were often larger than that[11]. Seven hundred *tonéis* was the estimated tonnage of the *Santa Catarina do Monte Sinai*[12], which in 1518 brought to Lisbon almost 470 tons of pepper and almost 18 tons of other items[13]. Of approximately the same size was the *Nazaré*, which in the same year carried a cargo of more than 491 tons, more than 463 of which was pepper[14]. In 1552, the galleon *S. João* carried 12,000 *quintais* (= 705 tons) of pepper when it wrecked near Port Edward in South Africa during its first voyage from India[15]. In 1590, the *Madre de Dios* carried 7,101 *quintais* (= 417 tons) of pepper; in 1594, the *Chagas* carried 9,800 *quintais* (= 575 tons)[16]. Contemporary texts on shipbuilding suggest that the remains of the *Nossa Senhora dos Mártires*, which in 1606 sank with its Indian cargo only a few miles off Lisbon, belonged to a ship of 600 *tonéis*[17].

Returning to the Roman period, the question posed here is whether it is possible to give an example of:

1. the carrying capacity of the 'very large ships' mentioned in the *Periplus*; and
2. the relative proportions between the two principal items of trade carried by these ships: pepper (which is dense and heavy) and malabathron (whose leaves tend to be bulky but light).

To date, existing evidence appeared to be insufficient to address these issues. I will argue here that a closer examination of one of the key sources of historical data on Indo-Roman trade, the 'Muziris papyrus', makes it possible to get some fresh data.

The Papyrus Vindobonensis G 40,822[18]—also known as the 'Muziris papyrus'—has on its verso (reverse) side the monetary values of a set of items. After the computation of the value of each single item, the last three lines of the almost entirely preserved second column (Col. II. ll. 27-29) provide the total for all the entries, with the specification that it represents three-quarters[19] of the items shipped out on a vessel named the *Hermapollon*. The tally is impressive: as Morelli now reads it, the total figure is 1,151 money talents and 5,852 drachmas[20]. Unfortunately, because of the fragmentary status of the papyrus, the data for only three cargo items are easily legible. All three are of either certain Indian origin (i.e., Gangetic nard) or likely Indian origin (i.e., 'sound' ivory and *schidai*[21]). The quantities and values are as follows:

Item	Quantity	Value
Gangetic nard	60 containers	45 talents
'Sound' ivory	78 talents 54¾ minae	76 talents 5,275 drachmas
Schidai	13 talents 9¾ minae	8 talents 5,882 drachmas 3 obols
Total	60 containers, 92 talents 4½ minae	130 talents 5,157 drachmas 3 obols

Taken together, the value of the three identified items amounts to 130 money talents, 5,157 drachmas and 3 obols, which constitute only about 11.36% of the entire cargo's value. This leads immediately to the question about what trade items made up the remaining 88.64% value.

Under most circumstances, any further speculation about the remaining cargo would have been fruitless, but two related lines of evidence may change that: the first is that the recto (front side) of the Muziris papyrus preserves a fragment of a loan contract for a voyage to Muziris, and the second is that the *Periplus Maris Erythraei* includes Gangetic nard and ivory among the merchandise available from the south Indian emporia of the Limyrike—one of which was Muziris[22]. Since the *Hermapollon*'s cargo is valuated on the verso side of a loan agreement for a commercial enterprise to Muziris and includes items known to be available at Muziris, it is very likely that this cargo was entirely imported from Muziris. If so, then there can be very little doubt that at least part of the remaining unidentified cargo on the *Hermapollon* included black pepper and malabathron—a conclusion further supported by the assertion in the *Periplus Maris Erythraei* that these ships were 'very big' in order to transport these two trade items.

Even if we accept that black pepper and malabathron made up the remaining value and weight of the *Hermapollon* cargo, it is still a challenge to speculate how much of each item was carried, and an even greater challenge to calculate how much each was worth. Such pertinent information would have been contained in the preceding Column I of the verso side of the papyrus, most of which is lost. What remains of Column I is meager—a few letters on its right margin, seemingly referring to weights and sums of money—and do not at first appear to be informative. However, a closer look at these signs, as shall be demonstrated below, does in fact lead to unexpected new data and insights.

Pepper

The limited interpretive potential of the verso text was further restricted by a couple of crucial misreadings made by the first editors and so far undetected. At Col. I l. 25 they read] μν(ῶν) (δραχμῶν) ψοα to mean 'mnai, drachmas, 771'. Such a reading is meaningless: it conjoins a unit of weight with a unit of currency in a single descriptive measure.

As a matter of fact the reading is evidently ἀργ(υρίου) (τάλαντα) ψοα, which means 'money talents, 771'. On the basis of this revised reading, one can argue that one of the unidentified cargo items listed in the fragmented Column I had a total monetary value of at least 771 talents, which would have been almost 67% of the total value of 1,151 talents and 5,852 drachmas. Such a considerable amount could have referred only to black pepper, the principal cargo item on the vessels trading between Egypt and south India in the first centuries AD. Although the figure of 771 talents does not allow us to estimate the actual

volume of pepper carried by the *Hermapollon*, it does demonstrate that black pepper constituted no less than two-thirds of the value of the cargo of the *Hermapollon*.

Another misreading by the first editors occurs in Col. I l. 26. They read (ταλάντων) δ (δραχμῶν) λβ, to be translated as '4 talents 32 drachmas'. The reading is clearly ᾽Δχλβ, namely the number 4,632, which is likely an amount associated with the currency unit of drachmas[23]. While this correction has little direct impact on the overall question of cargo value, it may lead to a better understanding of this portion of the papyrus.

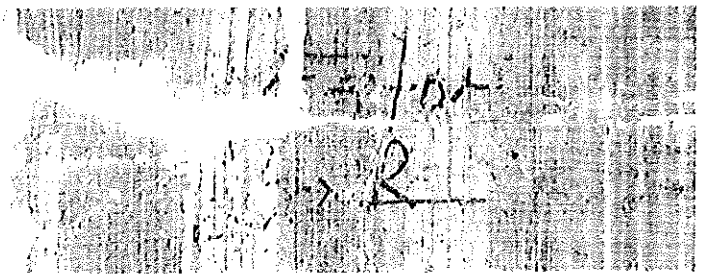

Fig. 3. P. Vindob. G 40822 verso Col. I ll. 25-26

The position of the amount of money mentioned at Col. I l. 25—just at the end of the line—makes it very probable that the 771 talents was just the first part of a sum that included some drachmas recorded in the next line[24]. On the other hand, it is also conceivable that the space in Col. I l. 26 that precedes drachmas 4,632 was deliberately left blank in order to isolate and make more readable a single monetary figure composed of both the talents (771) in l. 25 and the drachmas (4,632) in l. 26.

In other words, one can make the argument that the monetary value of (part of) the black pepper carried by the *Hermapollon* was 771 money talents and 4,632 drachmas.

How would this sum—771 money talents, 4,632 drachmas—have been worked out by the clerk who computed the monetary values recorded on the verso of the Muziris papyrus? To answer this question, we can refer back to the calculations of value laid out in Column II for Gangetic nard, 'sound' ivory, and *schidai*.

For each of these items, the value was calculated by multiplying either the number of containers (for the Gangetic nard) or their recalculated[25] weights (for the 'sound' ivory and the *schidai*) by their price per unit (4,500 drachmas per container of Gangetic nard, 100 drachmas per mina of 'sound' ivory, 70 drachmas per mina of *schidai*).

Theoretically, black pepper could be measured either by some container unit (such as sacks) or by actual weight. Its valuation therefore could be as straightforward as that of the Gangetic nard or as complex as those of the 'sound' ivory and the *schidai*. It is to be noticed, however, that while the valuation of the containers of Gangetic nard takes only three lines

of the text (Col. II ll. 1-3), those of the weights of 'sound' ivory and *schidai* require twelve (Col. II ll. 4-15) and ten (Col. II ll. 16-25) lines, respectively. Given that high numerical values are recorded at Col I ll. 20 and 21[26] and that Col. I ll. 22, 23 and 24 do not end with an amount of money, it is logical to suggest that the amount of money recorded at Col. I ll. 25-26 somehow relates to the high weight numbers at Col I ll. 20 and 21. This, in turn, makes it very probable that black pepper was measured by weight and that its value was calculated with a method similar to that of the 'sound' ivory and *schidai*.

The rather complex procedure by which the three-quarters of 'sound' ivory and *schidai* were valuated may be broken down into the following five steps:

1. Deduction of a small share of the import items, taken by the *arabarchai* (tax collectors) in addition for the *tetartologia*[27].
2. Recalculation of the remaining weight of the import item, using a heavier talent (while the standard talent of the custom office of the quarter-tax weighs 95 Roman pounds, these quotas of 'sound' ivory and *schidai* were recalculated with a talent weighing 97.5 Roman pounds).
3. Monetary valuation of the remaining weight by multiplying the weight number obtained in step 2 by the price per unit.
4. Monetary valuation of the shares 'taken' by the tax collectors by multiplying their non-recalculated weights by their prices per unit.
5. Sum of the monetary values obtained in step 3 and 4.

I would argue that a comparable process for the valuation of the pepper cargo can be discerned from the remains of Col. I ll. 20-28:

1. The weights recorded at ll. 20-21[28] may represent the quantity of pepper before (at l. 20) and after (at l. 21) the deduction of the share 'taken' by the tax collectors on top of the quarter-tax (Step 1).
2. The relative clause beginning with ἐξ ὧν ('from which') at l. 22 likely introduces the recalculation of the weight of pepper recorded at l. 21 (Step 2).
3. The amount of money at ll. 25-26 represents the monetary valuation of the remaining weight of pepper (Step 3).
4. At l. 27, the]μν(ῶν) μδ δ΄ ('44¼ minae')[29] likely represents the ending of the weight number corresponding to the share 'taken' by the tax collectors on top of the quarter-tax. In the missing lines below[30], its monetary value was calculated (Step 4) and
5. then added to the 771 talents and 4,632 drachmas (Step 5).

If the process of the monetary valuation of the pepper was indeed analogous to that of the ivory, then it is very likely that the amount of money recorded at Col I ll. 25-26 was

determined by taking a natural number of minae[31] and multiplying it by the price per unit. Since 4,630,632 drachmas (= 771 talents and 4,632 drachmas) is a multiple of 24, the price per mina must be either 24 or one of its submultiples: 12, 8, 6, 4, 3, 2, 1. The possible weights, therefore, that would result in the sum of 771 talents and 4,632 drachmas would be as follows:

Price per mina	Weight
1 drachma	77,177 talents 12 minae (= 2,366,716 kg)
2 drachmas	38,588 talents 36 minae (= 1,183,358 kg)
3 drachmas	25,725 talents 44 minae (= 788,905 kg)
4 drachmas	19,294 talents 18 minae (= 591,679 kg)
6 drachmas	12,862 talents 52 minae (= 394,452 kg)
8 drachmas	9,647 talents 9 minae (= 295,839 kg)
12 drachmas	6,431 talents 26 minae (= 197,226 kg)
24 drachmas	3,215 talents 43 minae (= 98,613 kg)

At first glance, the last option—24 drachmas per mina as price, connected to a weight of 3,215 talents 43 minae—appears to be the best fit. Indeed, 24 drachmas per mina is very close to the price of black pepper given by Pliny the Elder[32]. Furthermore, 3,215 talents is very close to the number (3,2?5) read by the first editors at Col I l. 21. Upon further consideration, however, neither argument seems to make a strong case. Regarding the price, Pliny is probably referring to retail prices in mid-1st century AD Italy, which may be different for pepper than the wholesale prices (or, rather, fiscal valuations) in mid-2nd century AD Egypt.

Regarding the weight, if 3,215 is the figure at Col I l. 21, then we must acknowledge that the weight of the pepper was not recalculated using a heavier weight unit for talents, as were the weights of the 'sound' ivory and *schidai*. But such an acknowledgment makes it difficult to understand the vast gap between the weight of the pepper at Col. I l. 21 and its monetary valuation at Col. I ll. 25-26. The 771 talents and 4,632 drachmas should result from the simple multiplication of weight and price per unit: both data—weight and price per unit—must have been recorded in the lost portion of l. 25. It is highly implausible that

the same weight at l. 21 was repeated there. On the contrary, a comparison with Column II makes it much more likely that the weight at Col. I l. 21 was recalculated with a heavier standard in Col. I ll. 22-24.

An alternate reading of 3,295 talents (the only other possibility, if the reading 5 is accepted) is also incompatible with the assumption that the weight recorded at l. 21 was recalculated using a heavier talent weight, when calibrated using natural numbers of Roman pounds and ounces. If translated into Roman pounds at the ratio of 1 talent to 95 pounds, and then back again into talents at the ratio of 1 talent to 97 pounds plus a natural number of ounces, a weight of 3,295 talents and x minae cannot lead to 3,215 talents and 43 minae[33]. Hence, paradoxical as it seems, the digits 3,000 + 200 at Col I l. 21 do not support the hypothesis that 3,215 talents and 43 minae is the missing weight figure at Col I l. 25. What is suggested instead is the weight figure of 12,862 talents and 52 minae.

If the weight at Col. I l. 21, measured with the official talent of 95 pounds, was 1]3,200 + x talents and y minae; if it was recalculated with a heavier talent, calibrated on a talent weighing natural numbers of Roman pounds and ounces; and if the result of the recalculation was 12,862 talents and 52 minae as the missing weight number to be restored at Col. I l. 25, then the weight at Col. I l. 21 should be one of the following:

Weight before recalculation (Col. I l. 21) (at 95 lbs per talent)	**Weight after recalculation (Col. I l. 25) (at ≥ 97 lbs 6 oz per talent)**
13,201 t. 22 m.	12,862 t. 52 m. (at 97 lbs 6 ounces per talent)
13,212 t. 12 m.	12,862 t. 52 m. (at 97 lbs 7 ounces per talent)
13,223 t. 2 m.	12,862 t. 52 m. (at 97 lbs 8 ounces per talent)
13,235 t. 13 m.	12,862 t. 52 m. (at 97 lbs 9 ounces per talent)
13,246 t. 3 m.	12,862 t. 52 m. (at 97 lbs 10 ounces per talent)
13,258 t. 14 m.	12,862 t. 52 m. (at 97 lbs 11 ounces per talent)
13,269 t. 4 m.	12,862 t. 52 m. (at 98 lbs per talent)
13,279 t. 54 m.	12,862 t. 52 m. (at 98 lbs 1 ounces per talent)
13,290 t. 44 m.	12,862 t. 52 m. (at 98 lbs 2 ounces per talent)

Taking into account what does remain visible at l. 21, we can suggest the following:

1. The correct reading at l. 21 is 1]3,223 talents and 2 minae. Such a reading does not seem impossible: I take as γ the long horizontal stroke and the oblique stroke located after the supposed ϵ[34]. Between the supposed ϵ and what I perceive as the oblique

stroke of the γ, I cannot see any sign—or even sufficient space—for the symbol for mina. In my opinion, the symbol for mina is after—not before—the γ. The γ, therefore, must be the last digit (3) of the number of talents. The preceding digit, situated between the hundreds (σ) and the units (γ), cannot be a 5 (ε), as read by the first editors. It must be a ten, very likely 20 (κ). Under the horizontal stroke and to the right side of the oblique stroke of the γ, I read the symbol for mina, followed by the remains of a letter compatible with β. My reading for what remains of l. 21 is thus:]'Γσκγ μν(ῶν) β, and the entire line should be restored as follows: [ὧν ὁμοίως τιμὴ λογίζεται ὁλκ(ῆς) μὲν (ταλάντων) μ(υριάδος) α] 'Γσκγ μν(ῶν) β.

2. The weight of 13,223 talents and 2 minae, measured with a talent of 95 pounds, was then arithmetically recalculated with a talent of 97.66 pounds (97 pounds and 8 ounces) through the simple equivalence (particularly functional for recalculating such enormous quantities of imported pepper) of 1,028 talents (of 95 pounds) = 1,000 talents (of 97.66 pounds).

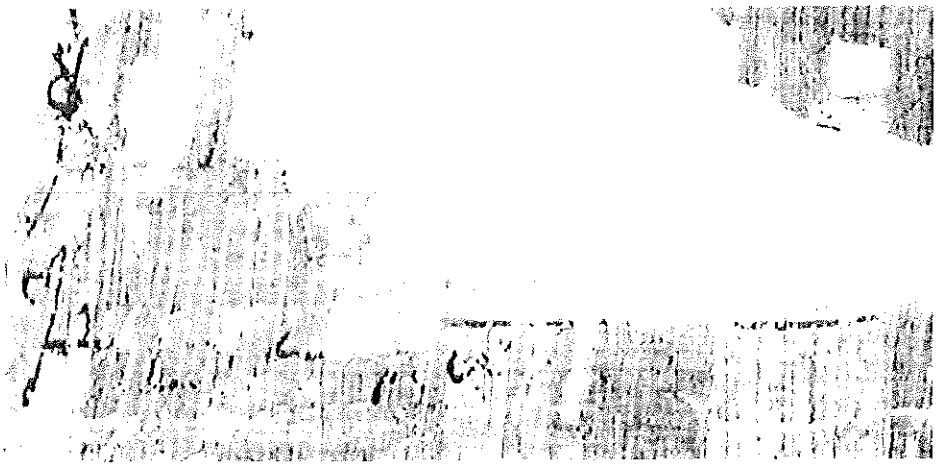

Fig. 4. P. Vindob. G 40822 verso Col. I ll. 20-21

The actual three-quarters of the *Hermapollon*'s pepper cargo was recorded at Col. I l. 20, where Morelli reads either]'Γτη (3,308) or]'Γτιε (3,315). The first reading seems preferable: as in Col. I l. 21, here I restore μ(υριάδος) α (10,000) before]'Γτη (3,308). The number of weight talents was therefore I]3,308.

To infer the number of minae, we should refer to the interpretation given by Morelli of Col. I ll. 4-13, who convincingly shows the following:

a. At Col. I l. 4 is recorded the number of containers of Gangetic nard corresponding to the quarter-tax.

b. At Col. I ll. 5-9 are listed:
   1. The entire quantity of 'sound' ivory imported by the *Hermapollon* (l. 5: here Morelli correctly reads '105' instead of the '120' read by the first editors);
   2. The quantities of 'sound' ivory corresponding to the sum of the quarter-tax and the share 'taken' by the tax collectors on top of the quarter-tax (l. 6);
   3. The quantity of 'sound' ivory corresponding to the share 'taken' by the tax collectors on top of the quarter-tax (l. 8);
   4. The quantity of 'sound' ivory corresponding to the quarter-tax (l. 9).

c. At Col. I ll. 10-13 are recorded:
   1. The entire quantity of *schidai* imported by the *Hermapollon* (l. 10);
   2. The quantity of *schidai* corresponding to the sum of the quarter-tax plus the share 'taken' by the tax collectors on top of the quarter-tax (l. 11: again, Morelli here correctly reads '4̲6' instead of '2̲6' as read by the first editors);
   3. The quantity of *schidai* corresponding to the quarter-tax (l. 13: Morelli rectifies as '4' what was read as '24' by the first editors).

On these premises, we can attempt an explanation of the data in Col. I ll. 1-3. It seems quite probable that the remains of the three weight numbers in Col. I ll. 1-3 (59 minae, 14¾ minae, 58 minae) relate to the black pepper, whose three-quarters are valuated—right before the Gangetic nard—at Col. I ll. 20 ff[35]. As Morelli noticed, the 14¾ minae of Col. I l. 2 is one-quarter of 59 at Col. I l.1; and 44¼ minae of Col. I l. 27 are the remaining three-quarters.

I suggest understanding Col. I ll. 1-3 as follows:

1. The weight of Col. I l. 1 (x talents + 59 minae) is the quantity corresponding to the sum of the quarter-tax and the share 'taken' by the tax collectors on top of the quarter-tax;
2. The weight of Col. I l. 2 (y talents + 14¾ minae) is the quantity corresponding to the quarter-tax;
3. The weight of Col. I l. 3 (z talents + 58 minae) is the quantity corresponding to a further deduction[36].

A quarter-tax ending with 14¾ minae must come from a total quantity ending with 59 minae; the remaining three-quarters must be a quantity ending with 44¼ minae. Recalling the 1]3,308 weight talents to be restored at Col. I l. 20, we may therefore conclude that:

1. The three-quarters of the pepper carried by the *Hermapollon* amounted to 13,308 weight talents and 44¼ minae;
2. The quantity of pepper corresponding to the quarter-tax amounted to 4,436 weight talents and 14¾ minae;
3. The entire quantity of black pepper carried by the Hermapollon was 17,744 weight talents and 59 minae.

Because the weight number of the total quantity of pepper ended with 59 minae, and because the sum of all the deductions (the quarter-tax, the share 'taken' by the tax collectors on top of the quarter-tax and the further deduction) amounted to a weight number ending with 57 minae[37], one can confirm that the weight number at Col. I l. 21 ends with 2 minae, giving additional support to reading the weight as talents 1]3,223 minae 2.

To sum up, the entire process of valuating the three-quarters of pepper imported by the *Hermapollon* may be reconstructed as follows:

1. From the weight specified at Col. I l. 20 (weight talents 1]3,308 [minae 44¼) of pepper, which represents the three-quarters of the total quantity imported by the *Hermapollon*, two different amounts (one of which is the share 'taken' by the tax collectors on top of the quarter-tax) are deducted. What remains is 13,223 weight talents and 2 minae.
2. This weight, measured with the official talent of 95 pounds, is then recalculated with a talent of 97.66 pounds. In practice, for each 1,028 official talents only 1,000 are counted. The result is the weight figure 12,862 weight talents and 52 minae.
3. The weight figure 12,862 talents and 52 minae is multiplied by 6 drachmas per mina (360 drachmas per talent). The resulting amount of money is 771 talents and 4,632 minae.
4. The quantity corresponding to the share 'taken' by the tax collectors on top of the quarter-tax is multiplied by 6 drachmas per mina.
5. 771 talents and 4,632 minae is added to the result of Step 4.

Malabathron and Tortoise Shell

Morelli's interpretation of Col. I ll. 4-13 makes it clear that the monetary valuation of the three-quarters of the cargo of the *Hermapollon* does not begin before Col. I l. 14. As the pepper section starts with Col. I l. 20, it follows that Col. I ll. 14-19 contained the valuation

of the three-quarters of the item (or items), that, together with pepper, Gangetic nard, 'sound' ivory and *schidai* made up the cargo of the *Hermapollon*.

Incorporating the calculations so far discussed in this essay, and assuming that the pepper 'taken' in addition by the tax collectors was 18 weight talents and 44 ¼ minae[38], valuated at 1 money talents and 745.5 drachmas, the values of the three- quarters of known and unknown items may be reconstructed as follows:

Items	Value of the three-quarters	
Pepper	772 talents	5,377.5 drachmas
Gangetic nard	45 talents	
'Sound' ivory	76 talents	5,275 drachmas
Schidai	8 talents	5,882.5 drachmas
Missing items	248 talents	1,317 drachmas
Total	**1,151 talents**	**5,852 drachmas**

Can we now determine how many items are missing and, in the case of multiple items, can we attempt to identify them and approximate their respective values and weights? The fractions at Col. I ll. 14, 17 and 18 make it clear that at the end of each of those lines were weight numbers ending with fractions of minae. On the other hand, the currency symbol of money talent at Col. I l. 19 shows that at the end of this line there was the monetary valuation of the item whose weight was specified at the end of Col. I l. 18.

We can eliminate the idea that lines Col. I ll. 14-19 concern just one item valuated with the methods applied to the Gangetic nard or the 'sound ivory' and *schidai* (and, as argued here, to pepper): the three weight numbers at the end of Col. I ll. 14, 17 and 18 are inconsistent with both those *modi operandi*. In my view, the most satisfactory explanation of what remains in Col. I ll. 14-19 is that two items are valuated, both measured by weight: 'missing item a' is valuated at Col. I ll. 14-16, and 'missing item b' is valuated at Col. I ll. 17-19. It appears that the valuation of these two items was worked out with a procedure different from either that of the Gangetic nard or that of pepper, 'sound ivory' and *schidai*. It diverges from the first one inasmuch as the items are measured by weight, and their weight numbers, given at Col. I ll. 14 and 17[39], undergo an alteration resulting in the weight numbers given at Col. I ll. 15 and 18[40]. Likewise, the valuation of these two items also departs from that of pepper, 'sound ivory' and *schidai*, as it does not anticipate all the manipulations connected with the share 'taken' by the tax collectors on top of the quarter-tax and the recalculation of weight with a heavier talent. After the alteration, the weight

numbers are immediately multiplied by their respective prices per unit, leading to the amounts of money recorded at Col. I ll. 16 and 19.

On these premises, the remains of Col. I ll. 14-19 show that:

1. The unaltered weight number of 'missing item a' ends with 31.5 minae (Col. I l. 14).
2. The altered weight number of 'missing item a' ends with 21 minae (Col. I l. 15).
3. The monetary value of 'missing item a' includes a number of drachmas ending with the digit 8 (Col. I l. 16).
4. The altered weight number of 'missing item b' (Col. I l. 18[41]) is 1,860 + x weight talents and y.75 (or y.25) minae.
5. The monetary value of 'missing item b' (Col. I l. 19[42]) is 220 + z money talents and y drachmas.

From the combination of these clues we deduce that:

1. The price per mina of 'missing item a' was a number ending with the digit 8.
2. The monetary valuation of 'missing item b' included a number of drachmas ending with the digit 9.
3. The price per mina of 'missing item b' cannot be higher than 12.36 or lower than 11.76 drachmas[43].

In turn, we may infer that:

1. The price per mina of 'missing item b' was 12 drachmas.
2. The monetary valuation of 'missing item b' was somewhere between 223 money talents 1,209 drachmas and 224 money talents 2,349 drachmas[44].
3. The monetary valuation of 'missing item a' was neither higher than 25 money talents and 108 drachmas nor lower than 23 money talents and 4,968 drachmas.

Both its weight and value designate 'missing item b' as the second major item in the *Hermapollon*'s cargo. In terms of weight, its ratio with pepper is approximately 1 : 7.35[45] and, in terms of value, roughly 1 : 3.5. It is virtually certain that 'missing item b' is malabathron, one of the two most heavy and/or voluminous items usually (re-)exported from the ports of the Limyrike at the time of the *Periplus Maris Erythraei*[46].

'Missing item a' is most likely one of the additional Limyrike exports listed by the *Periplus Maris Erythraei*. Silk, pearl, translucent stones, hyacinth and tortoise shell are all mentioned in the text along with pepper, malabathron, Gangetic nard and ivory[47]. The combination of a weight number greater than 21 minae (roughly 10.7 kg) with a monetary value not higher than 25 money talents and 108 drachmas precludes, in my opinion,

identifying 'missing item a' as pearl, translucent stones or hyacinth. The circumstance of the last digit of the price per mina being 8 also makes silk an unlikely candidate, since the price of silk could have been even higher than that of ivory and a round figure would be a more likely price. The most plausible option then is tortoise shell.

In Diocletian's edict on Maximum Prices, the price of tortoise shell (100 *denarii* per pound) is two-thirds of the price of ivory (150 *denarii* per pound)[48]. We may suggest that in the Muziris papyrus the price of tortoise shell was 48 drachmas per mina[49]. The weight mentioned at Col. I l. 15 would therefore be 51 talents and 21 minae and the monetary value recorded at Col. I l. 16 would be 24 talents and 3,888 drachmas.

Consequently, the weight of the malabathron (Col. I l. 18) would be 1,863 talents and 5 ¾ minae; its value (Col. I l. 19) would be 223 talents and 3,429 drachmas[50].

The Cargo of the *Hermapollon*

The addenda of the sum given at Col. II l. 29 (1,151 money talents and 5,852 drachmas) may now be reconstructed as follows:

Item	Price[51]	Value
Tortoise shell	48 drachmas per mina	24 talents 3,888 drachmas
Malabathron	12 drachmas per mina	223 talents 3,429 drachmas
Pepper	6 drachmas per mina	772 talents 5,377.5 drachmas
Gangetic nard	4,500 drachmas per container	45 talents
'Sound' ivory	100 drachmas per mina	76 talents 5,275 drachmas
Schidai	70 drachmas per mina	8 talents 5,882.5 drachmas

The valuated quantities were:

Item	Quantity[52]
Tortoise shell	51 talents 21 minae
Malabathron	1,863 talents 5¾ minae
Pepper	13,241 talents 46¼ minae
Gangetic nard	60 containers
'Sound' ivory	78 talents, 54¾ minae
Schidai	13 talents, 9¾ minae

The weight of the entire cargo was:

Item	Quantity
Tortoise shell	68 talents and 28 minae + 4/3 of the subtracted quota besides the quarter tax[53]
Malabathron	2,484 talents and 8 minae + 4/3 of the subtracted quota besides the quarter-tax[54]
Pepper	17,744 talents and 59 minae
Gangetic nard	80 containers
'Sound' ivory	105 talents and 13 minae
Schidai	17 talents and 33 minae
Total Weight	20,420 talents 21 minae + 4/3 of the subtracted tortoise shell and malabathron + 80 containers of Gangetic nard

Some 20,500 talents of 95 Roman pounds each correspond to more than 625 tons, 544 of which (87%) was pepper[55]. Even if the weight of the 80 containers of Gangetic nard was relatively modest[56], it is clear from this reappraisal that the weight of the rest of the cargo would be enough to qualify the *Hermapollon* as a 'very big' ship in the eyes of the traders of the Graeco-Roman world[57].

Notes

* I am very much obliged to Herr Prof. B. Palme, Leiter of the Papyrussammlung der Österreichischen Nationalbibliothek Wien, for all the assistance he kindly provided during my time at the Papyrussamlung. There, I discussed several problems raised by this text with Dr. Federico Morelli, who afterwards generously allowed me to read a draft of his paper. I have been glad to see that, independently of each other, we arrived at the same reading of Col. I ll. 27-28. In this work, I shall briefly refer to his convincing interpretation of verso Col. I ll. 4-13. Other aspects of his contribution will be dealt with elsewhere. Also, I should thank my colleague, Prof. M.R. Falivene, whose advice helped me greatly, as well as my students S. Bettinelli, M. Mancini, J. Montani, and M. Peloso.

1 PME 56: πλεῖ δὲ εἰς τὰ ἐμπόρια ταῦτα μέ<γι>στα πλοῖα διὰ τὸν ὄγκον καὶ τὸ πλῆθος τοῦ πιπέρεως καὶ τοῦ μαλαβάθρου. A translation is below, in the text. For the correction μέ<γι>στα, cfr. De Romanis 1996: 178-180, nt. 40. Because of their considerable size, the ships that sailed to Muziris (or Nelkynda) could accommodate on board 'cohorts

of archers' (Plin., n.h. VI 101), but had to reduce as much as possible the navigation in the northern part of the Red Sea: their main port was Berenice (Plin., n.h. VI 103), the southernmost Egyptian port on the Red Sea. – In general, on Roman trade and black pepper import from India, cfr. Thapar 1992; on pepper consumption in the Roman empire, Zappata 1994; Sidebotham 2011: 224-227.

2 PME 60: [...] ἐν οἷς τοπικὰ μέν ἐστιν πλοῖα μέχρι Λιμυρικῆς παραλεγόμενα τὴν γῆν, ἕτερα δ' ἐκ μονοξύλων πλοίων μεγίστων ἀφαῖς (Müller : ἀφῆς cod. Giangrande, Casson) ἐζευγμένα, λεγόμενα σάνγαρα, τὰ δὲ εἰς τὴν Χρυσῆν καὶ εἰς τὸν Γάγγην διαίροντα κολανδιοφωντα τὰ μέγιστα. "In these [sc. ports] there are ships which skirt the coast as far as Limyrike, others, called sangara, made of very big dugout canoes bound together by joints, and finally the ones which cross the sea towards Chryse and the Ganges, the very big kolandiophonta".

3 The two- or possibly three-masted sailing ship scratched on a sherd of rouletted ware found at Alagankulam, on the Tamil Nadu coast at the mouth of the Vaigai, the river that used to cross the Pandya capital Madurai, has been recognized as a Roman merchant ship by Casson 1997 and Tchernia 1998: 455-456. At Khor Rori, the ancient Moscha Limen, where ships coming back from Limyrike could stop by or winter (cfr. De Romanis 2009 : 645-653), a graffito on plaster with a two-masted sailing ship has been found: Avanzini 2008, p. 616, fig. 4. A three-masted ship in a rock-drawing near Myos Hormos: Peacock and Blue 2006 : 18; Tchernia 2011 : 85. A ship with a single mast in a graffito on a pottery sherd from Berenike : Sidebotham 2011: 202.

4 *Akanāṉūru* 149, 9.

5 Philostr., v. A. III 35: ὑποκείσθω δὲ ναῦς, οἵαν Αἰγύπτιοι ξυντιθέντες ἐς τὴν θάλατταν τὴν ἡμεδαπὴν ἀφιᾶσιν ἀγωγίμων Ἰνδικῶν ἀντιδιδόντες Αἰγύπτια, θεσμοῦ γὰρ παλαιοῦ περὶ τὴν Ἐρυθρὰν ὄντος, ὃν βασιλεὺς Ἐρύθρας ἐνόμισεν, ὅτε τῆς θαλάττης ἐκείνης ἦρχε, μακρῷ μὲν πλοίῳ μὴ ἐσπλεῖν ἐς αὐτὴν Αἰγυπτίους, στρογγύλῃ δ' αὖ μιᾷ νηὶ χρῆσθαι, σοφίζονται πλοῖον Αἰγύπτιοι πρὸς πολλὰ τῶν παρ' ἑτέροις καὶ παραπλευρώσαντες αὐτὸ ἁρμονίαις, ὁπόσαι ναῦν ξυνιστᾶσι, τοίχοις τε ὑπεράραντες καὶ ἰστῷ καὶ πηξάμενοι πλείους οἰκίας, οἵας ἐπὶ τῶν σελμάτων, πολλοὶ μὲν κυβερνῆται τῆς νεὼς ταύτης ὑπὸ τῷ πρεσβυτάτῳ τε καὶ σοφωτάτῳ πλέουσι, πολλοὶ δὲ κατὰ πρῷραν ἄρχοντες ἄριστοί τε καὶ δεξιοὶ ναῦται καὶ πρὸς ἱστία πηδῶντες, ἔστι δέ τι τῆς νεὼς ταύτης καὶ ὁπλιτεῦον, πρὸς γὰρ τοὺς κολπίτας βαρβάρους, οἳ ἐν δεξιᾷ τοῦ ἔσπλου κεῖνται, παρατάττεσθαι δεῖ τὴν ναῦν, ὅτε λῃζοιντο αὐτὴν ἐπιπλέοντες.–Of course, king Erythras is a mythical figure and his odd laws never existed. But the ships for which those stories were invented were very real.

6 Marco Polo, *Le divisament dou monde*, 158, 8: "E si vos di que cestes nes veulent CC marineres, mes elle sunt si grant qu'elle portent bien V^{M} esportes de pevre, e de tel VI^{M}"; *Il Milione*, 154, 7: "Queste navi vogliono bene .cc. marinai, ma elle sono tali che portano bene .v^{m}. sporte di pepe, e di tali .vj^{m}." Digby 1982 : 132; 139 suggests that the measure referred to by Marco Polo was either the Venetian *carica* (ca. 120 kg) or the Indian Ocean

bahâr (ca. 235 kg). However, contemporary readers of either the Franco-Italian or the Tuscan version would have understood 5,000 or 6,000 *esportes/sporte* of some 210-225 kg each, cfr. Ashtor 1982 : 475-476.

7 Corresponding to 235/282 tons, Prange 2011: 219, nt. 41.

8 D. Barbosa, *Livro em que dá relação do que viu e ouviu no Oriente*, Lisboa 1946, p. 160-161: "Estes no tempo que prosperaram nos seus tratos e navegação, faziam nesta cidade naus de quilha de mil e mil duzentos bahares de cárrega; estas naus eram feitas sem nenhuma pregadura, todo o tabuado cosido com tamisa, e as obras de cima mui desviadas de feição das nossas, sem nenhuma coberta. – Aqui carregavam toda sorte de mercadorias para todas as partes, e partiam desta cidade cada monção dez e quinze naus destas para o mar Roxo, Adem e Meca, onde vendiam muito bem suas mercadorias, algunas aos mercadores de Judá que, daí, as levavam em pequenos navios ao Toro, e do Toro iam ao Cairo e do Cairo a Alexandria, e daí a Veneza, por onde vinham ter a nossas partes, as quais mercadorias eram muita pimenta e gengibre e canela, cardamomo, miramulanos, tamarinos, canafístula, e toda sorte de pedraria, aljòfar, almíscare, àmbar, ruibarbo, lenho-aloés, muitos panos de algodões e porcelanas".– Niccolò de Conti also (in Poggio Bracciolini, *de uarietate fortunae*, IVp. 148, 555-560 Guéret-Laferté) describes Indian ships of considerable (2,000 'butts') tonnage: "naues fabricant quasdam longe nostris maiores, ad duum milium uegetum, quinis ueils totridemque malis. Pars inferior trino tabularum ordine contexitur ad ferendos impetus tempestatum, quibus maximis quatiuntur. Sunt autem naues distinctae cellulis ita fabrefactis, ut etiam, si qua eius portio collisa deficeret, reliqua pars integra perficiat cursum".– Additional evidence for pre-modern ships of considerable size trading between South India and Arabia is also provided by the stone anchors of exceptional weight (1.5 tons) found at Galle (Sri Lanka), at Qalhat (Oman), and off Kursadi island (Palk strait, between Tamil Nadu and Sri Lanka): Souter 1998: 331-342; Vosmer 1999: 248-263; Athiyaman/Jayakumar 2004: 1261-1267.

9 Domingues 2004 : 247-252.

10 Leis, e Provisões que El Rei Dom Sebastião nosso senhor fez depois que começou a governar, printed in Lisbon, 1570, (2nd edition Coimbra, 1816), p. 68-85 [non vidi]. A *tonel* of pepper (a cask 1.54 m high and 1.027 m wide at its maximum diameter) weighs approximately 13.5 *quintais* (= 793.179 kg): Costa 1977 : 82.

11 For a list of ships of the *Carreira da Índia* and their estimated tonnages, see Costa 1997 : 437-440.

12 Costa 1997 : 82.

13 Bouchon 1977 : x.

14 Bouchon 1977 : x.

15 B. Gomes De Brito, *História Trágico-Marítima,* I: "E partio tão tarde por ir carregar a Coulão, e lá haver pouca pimenta, onde carregou obra de quatro mil e quinhentas, e veio a Còchim acabar de carregar a copia de sete mil e quinhentas por toda com muito trabalho por causa da guerra que havia no Malavar".

16 Kellenbenz 1956 : 3-4.

17 Castro 2005 : 147-188.

18 Pictures both of recto and verso are available online (open access) at the website of the Papyrussammlung of the Österreichische Nationalbibliothek: http://aleph.onb.ac.at/F/?func=find-c&ccl_term=WID%3DRZ00001642&local_base=ONB08. At the time of the first edition, a fragment pertaining to verso Col. I l. 17-20 had been positioned upside down, with obvious consequences. A transcription is also available at http://papyri.info/ ddbdp/ sb;18;13167. Palaeography suggests a mid-2nd century AD chronology. First edition by Harrauer/ Sijpensteijn 1985. Afterwards, Thür 1987; Casson 1990; SB XVIII 13167 (Rupprecht 1993). Some new readings in the text of the verso: De Romanis 1998; Rathbone 2000. A much better edition of the verso is now offered by Morelli 2011. My translation of the text (at the end of the paper) incorporates the new readings I propose here (Col. I ll. 14; 18 and 21) and others proposed by De Romanis 1998, Rathbone 2000, and Morelli 2011. —This paper concerns only the text on the verso side. When reference to columns and lines is made, one must understand they refer only to columns and lines of P. Vindob. G 40,822 verso. I shall continue to label as 'Column I' and 'Column II' the two (partially) extant columns of the verso side. However, we shall see (cfr. nt. 35) that to the left of Column I there was one more column, which was the real Column I. Moreover, in reproducing or translating the text of the papyrus, I print with underlined characters the words or letters of uncertain reading. Square brackets mean the beginning ([) or the end (]) of lost or illegible text: words or letters that follow or precede are restored. Round brackets () include expansions of abbreviations.

19 Rathbone 2000 rectified the crucial reading at Col. II l. 27 ($\overline{\gamma}$ '3', rather than $\underline{\overline{\varsigma}}$ '6' of the previous editors) and showed that the sum given at Col. II l. 29 concerns only three-quarters of the cargo. His explanation of the deduction of one-quarter is that the quarter-tax was paid in kind. Van Minnen 2008: 237 maintains that, despite the appearances, the quarter-tax was actually paid in money and suggests that another document recorded the money transfer to the custom officers. I shall return to this question in a forthcoming paper.

20 Previous editors read 1,154 talents 2,852 drachmas. —The Greek word *talanton* (talent) may refer either to a currency unit (*argyriou talanton*) or to a weight unit (*holkes talanton*). As a money accounting unit, it notionally equaled 60 Roman gold coins (*aurei*) and comprised 6,000 drachmas. A drachma notionally equaled one Roman *sestertius* and comprised 6 obols. As a weight unit, a talent comprised 60 minae. Its real weight varied according to the different standards used in I-II cent. AD Egypt. At the time of the papyrus, the official talent of the custom office of the quarter-tax equaled 95 Roman lbs (=322.8 g). So a talent weighed around 30.666 kg.

21 As Rathbone 2000 : 45 realized (and Morelli 2011 : 221-222 confirms), the *schidai* must refer to ivory of a lower quality, broken or spoiled.

22 PME 56: φέρεται δὲ πέπερι μονογενῶς ἐν ἑνὶ τόπῳ τούτων τῶν ἐμπορίων (Müller: τούτῳ τῷ ἐμπορίῳ cod.) γεννώμενον πολὺ, λεγομένῃ Κοττοναρικῇ (Müller: λεγομένη Κοττοναρικὴ cod.). φέρεται δὲ καὶ μαργαρίτης ἱκανὸς καὶ διάφορος καὶ ἐλέφας

καὶ ὀθόνια Σηρικὰ καὶ νάρδος ἡ Γαγγιτικὴ (Stuck : Καπανικὴ cod.) καὶ μαλάβαθρον ἐκ τῶν ἔσω τόπων εἰς αὐτὴν, καὶ λιθία διαφανὴς παντοία καὶ ἀδάμας καὶ ὑάκινθος καὶ χελώνη ἥ τε Χρυσονητιωτικὴ καὶ ἡ περὶ τὰς νήσους θηρευομένη τὰς προκειμένας αὐτῆς τῆς Λιμυρικῆς. "They export pepper, abundantly grown in only one region of these markets, a district called Kottonarike. They also export a sufficient quantity of pearls of excellent quality, ivory, Chinese cloth, Gangetic nard, malabathrum from the places in the interior, transparent stones of all kinds, diamonds, sapphires and tortoise-shell, both from Chryse Island and that taken from among the islands along the coast of Limyrike". Aside from the Limyrike emporia, the author of the *Periplus* also notes (PME 63) the availability of Gangetic nard at the Ganges emporium (which is hardly surprising), but from nowhere else in India.

23 On the left of 'Δχλβ '4,632' there are slight traces of ink, which could be the remnants of the sign for that accounting unit.

24. If pepper was valued at a high denominator fraction of talent per unit (exactly as 'sound' ivory and *schidai* were: 1/60 and 7/600 of talent per mina, respectively), a sum of talents with no drachmas attached would be a remarkable coincidence. Absence of drachmas is less surprising, when the item is valued at a low denominator fraction of talent per unit. This is the case of the Gangetic nard, whose price per container (*kiste*) was three-quarters of a talent: the value of 60 containers was only 45 talents (Col. II ll. 1-3).

25 See below.

26 For their reading, see below.

27 Rathbone 2000: 46 explains the shares 'taken' by the tax collectors on top of the quarter-tax with the difficulty of levying a quarter-tax in kind on items such as ivory, which are not easily divisible into shares of weight that are arithmetically predetermined: the 'remaining tusks' and the 'remaining *schidai*' would be the extra weight taken in excess by the tax collectors. Moreover, he suggests that the double conversion of (part of) the three-quarters of the weights of 'sound' ivory and *schidai*—from talents to pounds at a *ratio* 1 : 95 and back from pounds to talents at a *ratio* 97.5 : 1—is an accounting artifice allowing the tax collectors to collect more than the stipulated 25%. However, if the shares 'taken' in addition by the tax collectors for the *tetartologia* depended on the rounding up of the quarter-tax, we would expect them to be recorded at the end of the process that determined the weight supposedly left to the merchants. The assumption that those shares depended on a rounding up is not consistent with the hypothesis that the subsequent double conversion of the weights aims at a further reduction—arithmetically determined—of the amounts which, in Rathbone's interpretation, would be given back to the merchants. Either the first or the second contention (or, more probably, both) must be wrong. In my opinion, the shares 'taken' by the tax collectors define a surcharge and the double conversion of the weights aims at adjusting the monetary value of the items. For their assessment see below nt. 38. I shall discuss this and other related questions in a forthcoming paper.

28 For their readings see below.

29 Morelli suggests as possible alternatives μβ̲ δ′ι′ '42̲ ¼' or μα̲ δ′ι′ '41̲ ¼'.

30 I assume that below Col. I l. 28 at least two lines are lost. Below Col. II l. 29 (maybe the last line of the text) there are at least 5 cm of blank space.

31 The shares of 'sound' ivory and *schidai* 'taken' by the tax collectors include the fractions of mina of the original amounts of the three-quarters (see below nt. 38). Therefore, the remaining quantities end with natural numbers of minae. We shall argue that the share of pepper 'taken' by the tax collectors include the fraction of talent of the original amount of the three-quarters. A further reduction of x talents and 58 minae leaves an amount ending with a natural number of minae.

32 Plin., n.h. XII 28: emitur in libras (denariis) XV, album (denariis) VII, nigrum (denariis) IIII. "it [i.e. long pepper] is bought for 15 *denarii* per pound; white pepper for 7, black pepper for 4". Four *denarii* per pound notionally correspond to 25.33 drachmas per mina.

33 The closest we can get is either 3,214 talents and 26 minae obtained from 3,295 talents and 59 minae, recalculated with a talent of 97 pounds and 5 ounces, or 3,216 talents and 7 minae obtained from 3,295 talents, recalculated with a talent of 97 pounds and 4 ounces. Nor can an adjustment from 3,295 and x minae to 3,215 talents and 43 minae be explained by a recalculation with a weight unit whose difference from the official talent was measured in simple fractions of mina (such a procedure occurs in POxy 2,580): the lighter talent would be between 58.53 and 58.55 minae of the heavier; the heavier would be between 61.47 and 61.49 of the lighter.

34 Of course, the γ is a little more spaced from the κ and its horizontal stroke extends longer than the usual pattern. I surmise that the clerk, thinking he had to write only weight talents 13,223, filled the blank space up to the end of the line with a long stroke, exactly as he does with the υ at Col. II l. 28. Subsequently, having realized that 2 minae had to be added, he wrote μν(ᾶν) β under the horizontal stroke of the γ.

35 As Col. I began with what we label as l. 1 and the document could not fail to mention the entire quantity of the pepper imported and the data related to the items evaluated in Col. I ll. 14-19, it necessarily follows that another entire column precedes Column I: therefore, the so-called 'Column I' is actually 'Column II' and the so-called 'Column II' is actually 'Column III'. This conclusion has serious implications for the general understanding of the text, which I shall address in a forthcoming paper.

36 We shall see below that the weights of the three-quarters of two other items of the cargo undergo a reduction that is not imputable to the share 'taken' by the tax collectors on the top of the quarter-tax.

37 14¾ + 44¼ + 58 = 1 weight talent and 57 minae.

38 The shares 'taken' by the tax collectors derive from round proportions of the rounded up amounts: 1 mina per 10 talents (ἑξακοσιοστή, 1/600) of 'sound' ivory (a total amount of 105 talents 13 minae, rounded up to 110 talents, makes 11 minae); 120 drachmae per 1 talent (πεντηκοστή, 1/50) of *schidai* (a total amount of 17 talents 33 minae, rounded up to 18 talents, makes 21.6 minae, rounded up to 22 minae); x talents per 1,000 talents of pepper (a total amount of 17,744 talents 59 minae, rounded up to 18,000 talents, makes

18 x talents). To these quantities the fractions of mina (for 'sound' ivory and *schidai*) or talent (for pepper) of the three-quarters of the total amounts were added. Consequently, we get 11¼ minae of 'sound' ivory, 22 ¾ of *schidai*, 18 x talents 44¼ minae of pepper.— In my reconstruction of the values of the three-quarters of the cargo, I assume that the tax collectors 'took' 1/1,000 (χιλιοστή) of the rounded up amount plus the fraction of talent of the total amount (44¼ minae). Of course, a different rate cannot be excluded, but it would imply only slight adjustments in the values of the pepper and the missing items.

39 At Col. I l. 14, I read λα L´ '31½'; the first editors had read ὁλ(κῆς) α L´ 'weight 1½'; Morelli reads μα L´ '41½'. At Col. I l. 17 I read] δ´ ']¼'; Morelli reads κγ δ´ '23¼'. The readings proposed by me are all compatible with the hypothesis that those weight numbers represents three-quarters of original quantities comprising only natural numbers of minae.

40 At Col. I 15 I accept Morelli's reading κα '21'. The first editors read σα.

41 At Col. I l. 18, I read 'Αωξ[('186[?'), Morelli's reading is 'Ασ[('1,2[??'). At the end of the line, I would read L´δ´ '½ ¼', Morelli reads .δ.´.

42 At Col. I l. 19 Morelli reads ἀργ(υρίου)(τάλαντα) σκ[('22[?'), but κ seems to me more clear than σ.

43 The higher limit is obtained by assuming that 229 money talents and 5,999 drachmas (the highest possible monetary value) was the value of 1,860 weight talents and one-quarter of mina (the lowest possible weight number); the lower limit supposes that 220 money talents and 9 drachmas (lowest possible monetary value) were the value of 1,869 weight talents and 59 ¾ minae (the highest possible weight number).

44 The first sum results from a quantity of 1,860 weight talents and three-quarters of a mina, the second from 1,869 weight talents and 55 ¾ minae.

45 But the ratio between their volumes must have been much less uneven.

46 Cfr. *supra* nt. 1. —Greek *malabathron* comes from Sanskrit *tamâlapattra*, 'leaf of *tamâla*'. Just like the Gangetic nard, the malabathron was imported to Limyrike from the Ganges emporion: PME 63. Pliny the Elder (Plin., n.h. XII 129), who fixes the price of black pepper at 4 *denarii* per pound (cfr. *supra*, nt. 32), states that the price of the malabathron may fluctuate between 1 and 300 *denarii* per pound, adding however that 60 *denarii* per pound is the price of the leaves themselves. At POxy 3,731 pepper and malabathron are both valued at 1 talent per pound. POxy 3,733 gives the pepper at 1 talent per pound and the malabathron at 2 talents per pound. In POxy 3,766 the pepper is 12 talents and the malabathron 50. It is worth noting that these data may provide additional reasons not to take 24 drachmas per mina (cfr. *supra*) as the price for pepper in the verso of the Muziris papyrus. While other documents show an equal or higher price for malabathron, it would be difficult to explain why black pepper should be worth double according to the Muziris papyrus. Moreover, the malabathron issue confirms the idea that Pliny is referring to prices that are higher than those assumed in the papyrus.

47 Cfr. *supra* nt. 22.

48 Edict. de pretiis: 16, 10-11. However, it is to be noticed that while in the Muziris papyrus black pepper is valued much less (6 drachmas per mina) than both 'sound' ivory (100 drachmas per mina) and *schidai* (70 drachmas per mina), its maximum price in the Diocletian edict (34, 68) is much higher (800 *denarii* per pound) than that of the ivory.

49 That is, 48% of the value of the 'sound' ivory and 68.5% of the value of the *schidai*. Alternatively, a value of 78 drachmas per mina (78% of the value of the 'sound' ivory, 111.4% of the value of the *schidai*) could be also considered.

50 If tortoise shell was valuated at a price of 78 drachmas per mina, its weight would be 31 talents and 21 minae; its value 24 talents and 2,718 drachmas. Consequently, the value of the malabathron would be 223 talents and 4,599 drachmas; its weight 1,864 talents and 43 ¼ minae.

51 Apparently, 'prices' are conventional and do not reflect market dynamics.

52 According to the quarter-tax official weight talent of 95 pounds. Quantities of pepper, sound ivory and *schidai* were re-calculated as 12,881 weight talents and 36 ¼ minae, 76 talents and 52 ¾ minae and 12 weight talents and 49 ¾ minae, respectively.

53 This is the difference between the weight numbers given at Col. II ll. 14 and 15.

54 This is the difference between the weight numbers given at Col. II ll. 17 and 18.

55 As the specific weight of pepper is 500/550 g per liter, 544 tons of pepper occupied approximately 1,000 m^3. — Average percentages of pepper in the cargoes of some Portuguese ships returning from India in the 16th and early 17th centuries are given by Steensgard 1985 : 22. In the period from 1513 to 1519 pepper was the 80% of the ships' cargo in weight; from 1523 to 1531, 84%; from 1547 to 1548, 89%; from 1587 to 1588, 68%; from 1600 to 1603, 65%; from 1608 to 1610, 69%.

56 The weight of the 80 containers (*kistai*) of Gangetic nard cannot be exactly established. However, since the containers must have been portable, the total final weight would have been rather inconsequential—one or two tons at most.

57 Pomey/Tchernia 1978; Tchernia 2011.

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P. Vindob. G 40822 verso: A Translation*

Col. I (II, actually)	
1. [---] 59 mn. 2. [---] 14¾ mn. 3. [---] 58 mn.	**Pepper**: quarter-tax + additional share 'taken' by the tax collectors(1); quarter-tax alone(2); further deduction(3).
4. [---] 20	**Gangetic nard**: quarter-tax.
5. [---] 167, 105 w. tal. 13 mn. 6. [---] 26 [w.] tal. 30 mn. 7. [---] of the quarter-tax 8. [---] likewise 11¾ w. mn. 9. [---] 26 [w.] tal. 18¼ mn.	**'Sound' ivory**: number of tusks and their weight (5); quarter-tax+additional share 'taken' by the tax collectors (6); additional share taken by the tax collectors alone (8); quarter-tax alone (9).
10. [---] 17 [w.] tal. 33 mn. 11. [---] 4 [w.] tal. 46 mn. 12. [---] ... 13. [---] 4 [w.] tal. 23¼ [mn.]	***Schidai***: weight (10); quarter tax + additional share taken by the tax collectors(11); quarter-tax alone (13).
14. [Of **Tortoise shell** ---]31½ [mn.] 15. [---]21 [mn.] 16. [---]8 [dr.]	**Three-quarters of the tortoise shell** weight (14); weight altered (15); monetary value (16).
17. [Of **Malabathron** ---] ¼ [mn.] 18. [---] 1,86[?] [w. tal.], ½ ¼ [mn.] 19. [---] 22[?] m. tal. [???9 dr.]	**Three-quarters of the malabathron**: weight (17); weight altered (18); monetary value (19).
20. [Of **Pepper**, 1]3,308 [w.tal. 44¼ mn.] 21. [--- 1]3,223 [w.tal.] 2 mn. 22. [---] from which ... 23. [---]... 24. [---]... 25. [---] 771 m.tal. 26. [---] 4,632 [dr.] 27. [---] 44 ¼ mn. 28. [---] — — — —	**Three-quarters of the pepper**: weight (20); weight minus the additional share 'taken' by the tax collectors and the further deduction (21); recalculation into a higher weight standard (22-24); monetary value (25-26); monetary value of the additional share 'taken' by the tax collectors and total monetary value (27 ff.).

* In the text of P. Vindob. G 40,822 verso, weight and money units are often abbreviated. To reproduce the abbreviated form I used w. tal.= weight talent(s); mn.= mina(e); w. mn.= weight minae; lbs.=pounds; m. tal.=money talent(s); dr.=drachma(s); m. dr.=money drachmas; ob.=obols. Sometimes, the clerk drops the specification of the nature of the talent (Col.II ll. 7,8,10,15,25). In those cases, however, the context makes it clear if it is a weight or a money talent. Unavoidably, the order of the words in my English translation doesn't strictly follow that of the Greek ones in the original text. Consequently, words and lacunae are sometimes shifted.

Playing Sudoku on the Verso of the 'Muziris Papyrus'

Col. II (III, actually)

1. Of **Gangetic nard**, 60 containers, of which likewise 2. the value is reckoned per container at 4,500 dr.: 3. 45 m.tal.	**Three-quarters of the Gangetic nard**: number of containers(1); price(2); value(3).
4. Of **'sound' ivory**, 78 w.tal. 54 ¾ mn., 5. of which likewise the price is reckoned thus: *a)* Of the 78 w.tal. 4[3] mn. 6. which—since, for the weight standard of the quarter tax, 7. the talent is reckoned at 95 lbs.—are 7,478 lbs.; 8. from which, being likewise reckoned pounds to talent 9. as it is usually reckoned for the merchants, is derived 10. 76 w. tal. 41 mn. At 100 dr. per mn.: 76 tal. 4,100 dr. 11. *b)* Of the remaining [---] tusks, taken in addition by the *arabarchai* for 12. the *tetartologia,* in the sum of tusks 13. together with the result, 11 ½ [¼] mn. 14. At the same 100 dr. per mn.: dr. 1,175. 15. Makes the total 76 tal. 5,275 dr.	**Three-quarters of the 'sound' ivory:** weight (4); weight minus the additional share 'taken' by the tax collectors (5); recalculation into a higher weight standard (6-10); monetary value (10); monetary value of the additional share 'taken' by the tax collectors (11-14); and total monetary value (15).
16. Of *schidai,* 13 w.tal. 9 ½ ¼ mn., 17. of which likewise the value is reckoned thus: *a)* Of the 12 w. tal. 4[7] mn., 18. which, as above, [---] for the weight standard of the quarter-tax, are 19. 1,214 lbs., in the way they are reckoned for the merchants, 20. 12 w. tal. 27 mn. At 70 dr. per mn.: 21. 8 m. tal. 4,290 dr. 22. *b)* The remaining *schidai,* taken in addition for the *tetartologia,* 23. as above, 22 ½ ¼ mn. At the 24. same 70 dr. per mn.: 1,592 m. dr. 3 ob. 25. Total for *schidai*: 8 tal. 5,882 dr. 3 ob	**Three-quarters of the *schidai*:** weight (16); weight minus the additional share 'taken' by the arabarchs (17); recalculation into a higher weight standard (18-20); monetary value (21); monetary value of the additional share 'taken' by the arabarchs (22-24); and total monetary value (25)
26. Total for the value of ivory: [85 m.tal. 5,157 dr. 3 ob.].	**Total value of the three-quarters of the ivory ('Sound' ivory + *schidai*) (26).**
27. In sum: Of the value of the 3 (*sc.* out of four) parts of the cargo 28. shipped out on the vessel *Hermapollon*: 29. 1,151 m.tal. 5,852 dr.	**Total value of the three-quarters of the cargo of the Hermapollon**

Weights and Money Units in P. Vindob. G 40,822 verso

Weights

Quarter-tax official weight talent (= 95 Roman lbs) = 30.666 kg	Mina (1/60 of a talent) = .5111 kg	Roman Pound 322.8 g (Duncan-Jones 1994 : 213-215)
Ivory recalculation weight talent (= 97.5 Roman lbs) = 31.473 kg	Mina (1/60 of a talent) = .52455 kg	
Pepper recalculation weight talent (= 97.66 Roman lbs) = 31.524 kg	Mina (1/60 of a talent) = .52541 kg	Roman ounce (1/12 of pound) 26.916 g

Money

Money Talent = 1,500 Egyptian tetradrachms 6,000 Egyptian drachmas Notionally equivalent to: 60 Roman golden *aurei* 1,500 silver *denarii* 6,000 bronze *sestertii*	Drachma = ¼ of Egyptian tetradrachm Notionally equivalent to: 1/100 of Roman golden *aureus* 1/4 of Roman silver *denarius* 1 bronze *sestertius*	Obol = 1/6 of Egyptian drachma