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In memoriam

LIGIAE BÂRZU

(1930-2003)

archaeologist and professor

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Some preliminary conclusions regarding the end of the Roman Provincial Coinage in *Dacia*

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Abstract: The topic of the present study represents a complex matter in the numismatics of the 3rd century AD. This is reflected by the multiple interpretations of the situation and the numerous aspects that could have affected the end of the Roman Provincial Coinage in the entire Roman Empire. If the monetary system had a dual character at the end of the 2nd century AD (composed of the local and central coinage), the situation would be completely different one century later. At that point, a new framework could be distinguished: the dual system was replaced by a centralized framework of coinage produced and controlled by the new system of imperial mints. *Dacia* represents an interesting case study for the mentioned phenomena. Taking into consideration the numismatic material, the mint of the province was active only during the chosen period for the present study. Besides, *Dacia* is an important case study for illustrating the effects of the central policies at the local level. The main question of the article: What were the causes of the end of the Roman Provincial Coinage in *Dacia*?

Keywords: *Dacia*, raids, coinage, crisis, mint.

Introduction

The territory of *Dacia* was an essential region in the Roman Empire. In the 3rd century AD, the province became one of the most relevant warfare zones, because of the multiple attacks of the threat of the Transdanubian tribes (the Carpi, Sarmatians, etc.). The chosen territory was also highly active in the provincial monetary production and circulation type during the 3rd century AD.

The Roman History of the period between the Severans and until the middle of Diocletian's reign (193-296 AD) is complex, and the events in other regions are also important, but the content of this study will be focused on *Dacia* to obtain a more precise and complete analysis of its situation. The numerous events that marked the region were critical elements in the development of the Roman Empire, which entered a period of 'crisis' at the beginning of the mentioned century. Even if the measures undertaken at the central level did not always have a direct influence on the types and quantities of coins minted in the provinces, the different coinage types are still interconnected. In the 3rd century AD, it is also visible how the external threats and the Roman policy regarding them affect in multiple ways the provincial coinage, including the one of *Dacia*.

At the beginning of the studied period, it could be observed how the imperial coinage was accompanied by local

production in the Balkan, Eastern, and Southern provinces. This analysis will reflect the exciting shift from a dual monetary system to a unified one, a change that happened during the 3rd century AD. In 294-296 AD, the Roman monetary system had a new framework in which a unified currency system existed. Latin became the only language used in the legends of the coinage, and the only mints that existed were the imperial ones.¹

***Dacia* – a brief chronology of its coin circulation and production**

The Roman province of *Dacia* was founded in 106 AD after the two Dacian wars between the local king, Decebal, and the emperor Trajan. The new Roman sphere of influence included the region between the Carpathian Mountains, the Danube, and River Olt (Fig.1).² The new province was administered by a *legatus Augusti pro praetor*.³

The mentioned details regarding the foundation and its status are essential for the context of further discussions.⁴ As far as the right to mint coins is concerned, the situation in *Dacia* differs from that in *Moesia Inferior*. If the cities of the latter territory could strike their own coins⁵ and use them in daily transactions, *Dacia* didn't have this quality until the reign of Philip the Arab.⁶ This mint's activity was influenced by various aspects of the imperial economic, political, and military development.⁷

During Septimius Severus' reign, the army's payment was substantially increased. An important aspect is that this type of subsidy consisted of silver coins, especially *denarii*, and with Septimius Severus' reign, the provincial coinage was also part of the soldiers' salaries.⁸ In connection with the new soldiers' payment, the emperor raised the production of the coins by reducing their fineness. For example, in 195 AD, the *denarii* of Rome became a coin with 40 % silver. This was a high decrease knowing that at the beginning of the same year, the *denarius* had 70% silver.⁹ But not only the silver coinage was affected. Rome's *officinae* started to produce smaller quantities of bronze coinage, and the *sestertius*, *dupondius*, and *as* were rarely issued.¹⁰ The same phenomenon – the decrease in the level of bronze coinage – was also present in *Dacia*'s case (Fig.2).¹¹

The graph based on the data collected and presented by Cristian Găzdac in his work *Monetary circulation in Dacia and the provinces from the Middle and Lower Danube from Trajan to Constantine I (AD 106-337)* reflects several vital elements of the evolution of coin production in the studied period and territory (Fig. 2). The effect of Severus' reform regarding the *denarius* is visible in the statistics. Between 193 and 238 AD, the *denarius* remained the main silver denomination based on the high rate of this type of coin found on the territory of *Dacia* (46.4%).¹² The data provided in Figure 3 regarding the evolution of the *antoninianus* illustrates the increased debasement of the coin starting with 238 AD.

¹ Estiot 2012, 538.

² Map 1. Roman *Dacia* - Găzdac 2010.

³ Găzdac 2010, 50.

⁴ Piso 2023, 111-2.

⁵ Dima 2018, 55-7.

⁶ Pick 1898, 1.

⁷ Varbanov 2005, 33; Piso 1974, 306.

⁸ Duch 2017, 84; Dima 2018, 55-7.

⁹ Metcalf 2012, 504.

¹⁰ Abdy 2012, 504.

¹¹ Găzdac 2010, 151.

¹² Table E1 - Găzdac 2010.

This process could mean a higher quantity of bronze and other base metals used to produce the silver currency, and, from this point of view, the debasement of the silver coinage could have led to a scarcity in the supply of bronze.¹³

Before the creation of the mint of *Dacia* (246 AD), the emperor opened one at *Viminacium* (239 AD), which was in charge of the bronze coinage supply of the region. This measure came as a result of the high amount of production of civic Greek coins, but also of the “cast” (plated) coins of bronze (Fig.2).¹⁴ Even if the mentioned mint was the principal source of coins of the neighboring provinces, *Dacia* was still in a difficult situation. This shortage of bronze coinage there reflected the necessity of local production that would happen through the mint of *Dacia* starting from 246- 247 AD. It is argued that the starting point of the minting in the province was the campaign of Philip the Arab against the Carpi. The mentioned years are considered the local year I of *Dacia* according to the system of minting registered on the coins. Each of them bore the year of its production.¹⁵

During these years, the territory of *Dacia* also became an important zone of warfare with numerous troops. Because of this new reality, numerous regions of the Empire began to strike their own coinage, including the “cast” bronze coins. As visible in Figure 2, this type of coinage reached high levels in 193-218 AD (36.7%), 218-238 AD (21.2%), and 238-244 AD (16.1%).¹⁶

Considering this context, the Empire decided to open new mints which had to produce bronze coins according to the system from Rome. This could have also been the case for *Dacia*. In the specialized literature, a possible role of supplier of the troops for *Dacia* is mentioned: ‘These coins were most probably minted chiefly to supply the troops in this area with good bronze coin.’¹⁷ A relevant argument could be that most of the bronze coin finds from the site of *Porolissum* (one of the most important sites from Roman *Dacia*) were found in the military zones (64%), and less in the settlements (36%) (Fig. 4).¹⁸

First of all, a mandatory aspect of the presentation of this mint is its typology. Generally, the Roman Provincial Coinage consists of five groups: the coins of ‘client kings’ (for example, the issues of King Sauromates II from the Bosporan Kingdom), the provincial issues; (they were produced in large quantities sufficient to supply specific regions of the Empire), ‘koinon’ coins, the alliance coinages, and the civic coins.¹⁹

Regarding the PROVINCIA DACIA coinage, it was part of the ‘provincial issues’ group and had several characteristics. Depicted on the obverse were the Roman emperors or the members of their families with a legend that contained the official elements and titles of the rulers in Latin. On the reverse, PROVINCIA DACIA is represented by a female figure accompanied by an eagle and a lion (symbols of the two legions: the *13th Gemina* and *5th Macedonica*). Another aspect is the location of the mentioned mint. This topic provoked numerous debates in the literature. The two centers of the mint that are primarily commented on by the researchers are *Ulpia Traiana Sarmizegetusa* (the residence of the *concilium*

¹³ Estiot 2012, 541-3.

¹⁴ Table E1 - Găzdac 2010.

¹⁵ Pick 1898, 3; Găzdac, Alföldy-Găzdac 2005, 145.

¹⁶ Table E1- Găzdac 2010.

¹⁷ Găzdac 2004, 136.

¹⁸ Găzdac, Alföldy-Găzdac 2005, 655.

¹⁹ Typologies presented on the Roman Provincial Coinage online platform accessed at <https://rpc.ashmus.ox.ac.uk/introduction/whatisrpc> on 1.06.2023.

Daciarum trium) and *Apulum*, where *legio 13th Gemina* had its garrison. In the mint from *Viminacium*, the authority on the coinage was the *concilium provinciae*. This idea was also applied in the case of *Dacia*. Currently, the location of the mint is considered *Ulpia Traiana Sarmizegetusa* more probable.²⁰

For *Dacia*, the Carpic invasions and the emperor's intervention here in 245/6-247 AD²¹ could have been the reason for the intense production of PROVINCIA DACIA coinage during the first year of its production (Fig. 5-6). This year, the production of local coinage represented 51.7% of the total coin finds. After this first year, the production of PROVINCIA DACIA coinage continued to decrease. This confirmed that the opening of the mint from *Dacia* was just a temporary measure for the supply of coinage in the region. The percentage of this type of coin from the next period (249-253 AD) is drastically lower: 15.5% (Fig. 5). Also, the devaluated *antoninianus*, which in this period contained only 15% of silver needed to be produced in higher numbers for the payment of the troops, reached a rate of 50.4% in the coin finds from the province of *Dacia* (Fig. 5).²²

The role of intensive hoarding during the study period is also reflected in the case of *Dacia*. The periods of warfare (the invasions of the Carpi and other tribes) are also the ones with the highest number of hoards ending with specimens from the time. In *Dacia*, the coin hoards (Fig. 7- 8) that ended during the reigns of Gordian III, Philip the Arab, and Trajan Decius are the most numerous out of all the hoards ending with coins between 193 and 275 AD (42 out of 62) (Fig.7).²³

The problematic context from the middle of the 3rd century AD (the numerous raids) affected *Dacia*. It is argued that the numerous attacks from the years 248-257 AD led to a considerable increase in the fragility of the strategic position of *Dacia*. The immediate consequence was the transfer of numerous military units to other places of the Empire. This measure might represent the beginning of the abandonment of the province by the Roman administration and army. The army had a strong impact on the development of the monetary circulation in the province. Practically, the primary role of the mint of *Dacia* was to provide the coin supply for the legions present there. If these troops are transferred to other regions, then the need for this type of monetary production is also moved. Considering this fact, the movement of these troops²⁴ to northern Italy and Gaul could be a reason for the scarcity of local coinage here.²⁵

The decrease in the provincial issues of *Dacia* is even more visible between 253 and 268 AD – only 7.8% (Fig. 5).²⁶ This percentage could be explained through various elements. One of them is the already mentioned gradual abandonment of the province, a process that is even more visible in 253-256 AD when more troops from *Dacia* were dispatched for the campaign of Valerian I's in the East. This moment reflects the end of the role of the local mint. This stage is also the one in which the end of the local coin production is usually dated (257 AD), so, as a result, the mint of *Dacia* had a short period of activity.²⁷ In the next part of the article, an attempt to reconstruct the possible explanations would be made.

²⁰ Găzdac, Alföldy-Găzdac 2008, 145.

²¹ Touratsoglou 2006, 137-8.

²² Table P1 – Găzdac 2010.

²³ Data generated through the online platform CHRE- Coin Hoards of the Roman Empire.

²⁴ A detailed description of the possible influence of this aspect on the studied phenomenon would be presented in the final part of the article.

²⁵ Găzdac, Alföldy-Găzdac 2008, 143.

²⁶ Table P1 – Găzdac 2010.

²⁷ Găzdac, Alföldy-Găzdac 2008, 146.

Several preliminary explanations of the studied phenomenon

The end of the Roman Provincial Coinage in *Dacia* was a cumulative result of the central and local evolutions. Both the barbarian attacks and the imperial monetary and military policy influenced the destiny of the mint.²⁸ In the first place, an element that attracted attention was the fact that the mentioned event was strongly influenced by the relationship between the central and local coinage, and this is highly visible for *Dacia* (Fig. 2, Fig. 5).²⁹

Between 193-296 AD, the Empire underwent serious changes. Rome's imperial institution was characterized by new elements: short reigns, the difficulty of establishing a dynasty (an important element throughout Roman history), and the continuous change of its relationship with the army. All the mentioned aspects contributed to the instability of the Empire, and it could be considered that was hard to maintain a stable monetary system in the context of the rapid succession of rulers and usurpers, and successive massive attacks on the frontiers.³⁰ Practically, during the Severans the situation was relatively stable, but in a short time, the context became more and more difficult from various points of view.³¹

The army started to have an increasing role in the state's affairs and their payment was also raised from the period of Septimius Severus' reign.³² Cassius Dio mentions an interesting piece of advice that the emperor gave to his sons: 'Be harmonious, enrich the soldiers, and scorn all other men.'³³ This measure affected the economy of the Roman Empire as the increase in the soldiers' salaries contributed to a powerful rise in military payments and to the debasement of the silver currency (the most used for the army). This devaluation could be identified two times in the studied period when the expenditures of the Empire were strongly increasing.³⁴

The *denarius* was the silver coin that was debased from the period of Septimius Severus. The decrease in the silver fineness of the coins led to a more consistent use of bronze or other base metals for the production of the *denarius*. The main consequence was the decrease in the presence of imperial bronze in the Empire, an element that was visible in *Dacia* (Fig.2).³⁵

The other coin that was debased during the period of the study was the *antoninianus*. This example has an interesting path. It was introduced by Caracalla as a temporary measure. After this, it was not produced anymore until 238 AD, when Pupienus and Balbinus revived the denomination.³⁶ This story is one of reference in the present study, because of its significance on both central and local levels. Figure 3 shows the debasement of the new silver currency, that is relatively slow until 250 AD. After this year, the devaluation reached new peaks and the so-called silver became a bronze coin because of its low level of precious metal (253 AD – 35 % silver, 260 AD – 15 % silver, 268 AD – 2.5 % silver).³⁷

²⁸ Touratsoglou 2006, 144-5.

²⁹ Table E1, P1– Găzdac 2010.

³⁰ Mennen 2011, 46-9.

³¹ Corbier 2007, 333-6.

³² Boteva 2010, 232; Boteva 1998, 77-80.

³³ Dio Cass., LXXVII, 15, 2.

³⁴ Duch 2017, 84.

³⁵ Table E1 - Găzdac 2010.

³⁶ Touratsoglou 2006, 165.

³⁷ Estiot 2012, 543.

The dynamics of the central monetary system had important effects on the local production of coinage. Figure 2 shows the strong relationship between the imperial and provincial coinage in *Dacia*'s case. Here, in the period between 244 and 249 AD, the *antoninianus* represents a percentage of 25.4%, while bronze coinage prevails (for example, the *sestertius* – 52.3%). After this year (249 AD), the relationship between the two types of coinage changed, and the *antoninianus* started to dominate the monetary circulation (249-253 AD – 55.9 %; 253-268 AD – 89.8%).³⁸

Between 253 and 268 AD, the state's economic development entered a new stage during Gallienus and Valerian I's reign.³⁹ Mints in the proximity of the army started to be used intensively for the production of imperial issues of debased *antoniniani*. Relevant examples are *Trier*, *Mediolanum*, *Siscia*, and *Cyzicus*. But this was not the only decision. The mint of Rome also underwent multiple changes: the number of *officinae* was increased from six to twelve.⁴⁰

These new measures were also visible in the monetary circulation from *Dacia*. When the local coinage was at its lowest level, the mint of Rome was again strongly present through the coin finds with a percentage of 56.2%. The other mints were also represented as follows: *Mediolanum* – 7%, *Siscia* – 7%, *Cyzicus* – 5.4% for 253-268 AD (Fig. 10). During the following periods, these imperial mints were present in an increasing percentage. For example, the mint from *Siscia* had in 268-275 AD 22.6% of the total coin finds in *Dacia*, which is an impressive and considerable development compared to the previous time frame.⁴¹ It is clear that the mentioned stage had relevant consequences: the imperial coins were flooding the space of the whole Empire, and the provincial coinage gradually decreased in production. It could be stated that the end of the Roman Provincial Coinage in *Dacia* was part of a bigger process at the scale of the entire Roman Empire.⁴²

As far as the military dimension is concerned, the raids of the 3rd century AD powerfully affected *Dacia*. Until 250 AD, its situation was relatively stable (Fig. 6). The creation of the mint is also linked to Philip the Arab's campaigns against the Carpi in 246-247 AD. After these campaigns, the imperial interest shifted to other regions such as Gaul and the northern part of the Italic peninsula. Because of this, troops were moved to these particular regions and the local production decreased. The mentioned aspect is an argument for the combination of military and economic factors. When the soldiers and, later the Roman administration were moved to other territories the mint of *Dacia* gradually lost its role.⁴³

The movement of legions and troops was part of the gradual abandonment of the province by the Roman army and administration. There are numerous perspectives regarding the event. Constantin Petolescu affirms that the reign of Gallienus marked the loss of *Dacia*, and Aurelian was the emperor who just officially abandoned the province.⁴⁴ Besides this opinion, D. Ruscu presumes that it could have been possible that just a part of the Roman administration and army left *Dacia* during the 260s⁴⁵ and that the final abandonment was during Aurelian's reign.⁴⁶ Considering the possibility that the process started during Gallienus' reign (253-268 AD), the end of the Roman Provincial Coinage in

³⁸ Table E1 - Găzdac 2010.

³⁹ Corbier 2007, 349.

⁴⁰ Corbier 2007, 349.

⁴¹ Table P1 - Găzdac 2010.

⁴² Bowman, Garnsey, Cameron 2007, 348.

⁴³ Găzdac, Alföldy-Găzdac 2008, 142-143.

⁴⁴ Petolescu 1995, 124-129.

⁴⁵ Ruscu 2000, 272; Ruscu 2003, 212.

⁴⁶ Ruscu 2000, 273; Ruscu 2003, 234.

Dacia could be linked with the decrease of the imperial presence here (the level of provincial issues – 7.8% – Fig. 5).⁴⁷

The concept of this gradual abandonment could be demonstrated by comparing coin finds from the Northern part and the Southern part of *Dacia*. Between 249 and 284 AD, the shift from the North to the South is visible. If in 249-253 AD the northern finds prevailed over the southern ones – 72 pieces and 33 pieces, respectively – the situation changed in the next periods. In 253-268 AD, during Gallienus' reign, the southern coin finds reached a number of 58 pieces, and in 268-275 AD they summed up to 113 pieces. Comparing these numbers with the ones of northern coin site finds (253-268 AD = 70; 268-275 AD = 30), the growing coin finds from the southern sites reflect the movement of troops and people to the South of the Danube (Fig. 9).⁴⁸

For *Dacia*, it could be considered that the low percentage of coin hoards which end with issues of Trajan Decius (8.87%), Trebonianus Gallus (9.67%), and the next ones compared to the coin hoards ending with the coinage of Philip the Arab (33.06%) verify the idea of the gradual movement of troops from here to other provinces (Fig. 7).⁴⁹ It could be considered that most coin hoards of *Dacia* could have resulted from the expenditures of the army present in the province.⁵⁰

Considering the presented aspects of the evolution of *Dacia* in the studied period, several preliminary explanations for the mentioned phenomenon could be stated. In the first place, if the right to produce coins was given to each of the mints by the imperial authority, then the decision that the same mints cease their production could have also been a central measure because of the challenging context in which the imperial monetary system found itself. Even before the *antoniniani* were in the last stage of their devaluation, the problems that they were provoking in terms of exchange were affecting the Empire negatively. When the quantity of silver used for the coin was less than 50% (42% in 238 AD and 35% in 253 AD⁵¹), the amount of bronze existing in the coin was far more than the one of silver. In this context, the possibility of establishing a stable exchange ratio between the so-called silver coinage and the bronze one (both central and local) was extremely difficult. Sylviane Estiot mentions the crisis of the bronze coinage on the central level: 'The striking of bronze became ruinous for the issuing authority, and its rate of exchange could not be maintained against a silver piece that had become in fact a simple copper token that has silver only in theory.'⁵²

If the coinage of *Dacia* was produced according to the patterns from Rome, it could be considered that the end of the provincial minting here could have also followed the central evolution. The local coinage in *Dacia* ended in 257 AD. This moment corresponds with the period in which bronze coinage gradually stopped being produced in the entire Empire, an aspect confirmed by Roger Bland who mentions that the last major production of this coinage is dated during the reign of Valerianus and Gallienus.⁵³ As far as these details are concerned, it seems clear that the end of the provincial bronze coinage was part of the broader process at the level of the Empire, a process that ended with a unitary system of coin production.⁵⁴

⁴⁷ Table P1 - Găzdac 2010.

⁴⁸ Table R2 - Găzdac 2010.

⁴⁹ Data provided through the online platform CHRE (Coin Hoards of the Roman Empire).

⁵⁰ Găzdac 2010, 146.

⁵¹ Estiot 2012, 543.

⁵² Estiot 2012, 541.

⁵³ Bland 2012, 525.

⁵⁴ Bowman, Garnsey, Cameron 2007, 348.

Aurelian and Diocletian's reforms had an essential influence on the new economic framework of the Empire. When Aurelian came to power, the situation was critical. He punished the workers of the central mint of Rome, who were the main ones responsible for actively worsening the process of debasement of the coinage. They were sent to *Serdika* – the minting center in one of the new *Dacian* provinces (one of the provinces created after abandoning the old province north of the Danube). After their punishment, the reform of Aurelian was introduced in 274 AD, and its main scope was to reintroduce the trimetallic system from the time of Caracalla. This marked the appearance of the *aurelianus* with a weight of 4.03 g. The other element of the system was *laureate denarius*. The *aureus* was also stabilized at its level from the period of Caracalla. Besides the new structure of the monetary system, the network of mints was changed compared to the earlier stages.⁵⁵ Even from Aurelian's period, we could observe the growing importance of the imperial mints that were producing the reformed coinage (8 mints – *Lyon, Rome, Ticinum, Siscia, Serdika, Cyzicus, Antioch, and Tripolis* with 39 *officinae*).⁵⁶

The next step in the evolution of the monetary system of the Roman Empire was the reform of Diocletian, which finalized its centralisation and the abandonment of dualism. The components of the new imperial monetary framework were: the *argenteus* (80% silver), the *nummus* (with the universal type *GENIO POPULI ROMANI* and 4% silver), the *neo-aurelianus*, *neo-denarius*, and *denarius communis*.⁵⁷ These two reforms mark the final stages in the reformation of the coinage of the Empire. In this complex process, the end of the Roman Provincial Coinage came in 296 AD with the end of the local minting in *Alexandria* and marked the shift to a new system based on the imperial coinage and its centers of production. This development was caused by multiple factors: local and central, but also military, political, and economic.⁵⁸

The external threats had an important influence on the fate of the coinage, but the situation was mainly influenced by the Roman policy in the region and in the whole Empire. When the local minting in *Dacia* was at its peak, there was an important number of troops and legions (the 5th *Macedonica*, 13th *Gemina*), but because of the increase in conflicts in the other parts of the Empire, multiple troops were moved to other regions. As a result, its role disappeared with the gradual abandonment of the province.⁵⁹ Besides this aspect, because of the accelerated debasement of the *antoninianus* after 250 AD (the period of a drastic decrease in the production of *Dacia*), it was harder to maintain both silver and bronze currencies at a healthy level of exchange. Because of this, the bronze coinage started to not be produced anymore, and, in consequence, the provincial bronze also stopped gradually in the whole Empire.⁶⁰

The answers presented in the current study are several preliminary conclusions for the subject of the end of the Roman Provincial Coinage in *Dacia*. The subject is very complex, and it implies more detailed research that would be continued further. The present work is a general image of the topic which is essential for a deeper understanding of the events regarding this component of the Roman monetary system. The clear aspect is that the end of local coin production was caused by the combined action of the political acts, the raids, and not at the very least, the economic development

⁵⁵ Estiot 2012, 545-6.

⁵⁶ Bowman, Garnsey, Cameron 2007, 349.

⁵⁷ Estiot 2012, 548.

⁵⁸ Metcalf 1987, 157-168.

⁵⁹ Găzdac, Alföldy-Găzdac 2008, 142-143.

⁶⁰ Estiot 2012, 541.

of the Empire between the Severans and the end of the 3rd century AD. At this stage, the traditional ways of research blended well with the tools of Digital Humanities and contributed to the presentation of the chosen topic.

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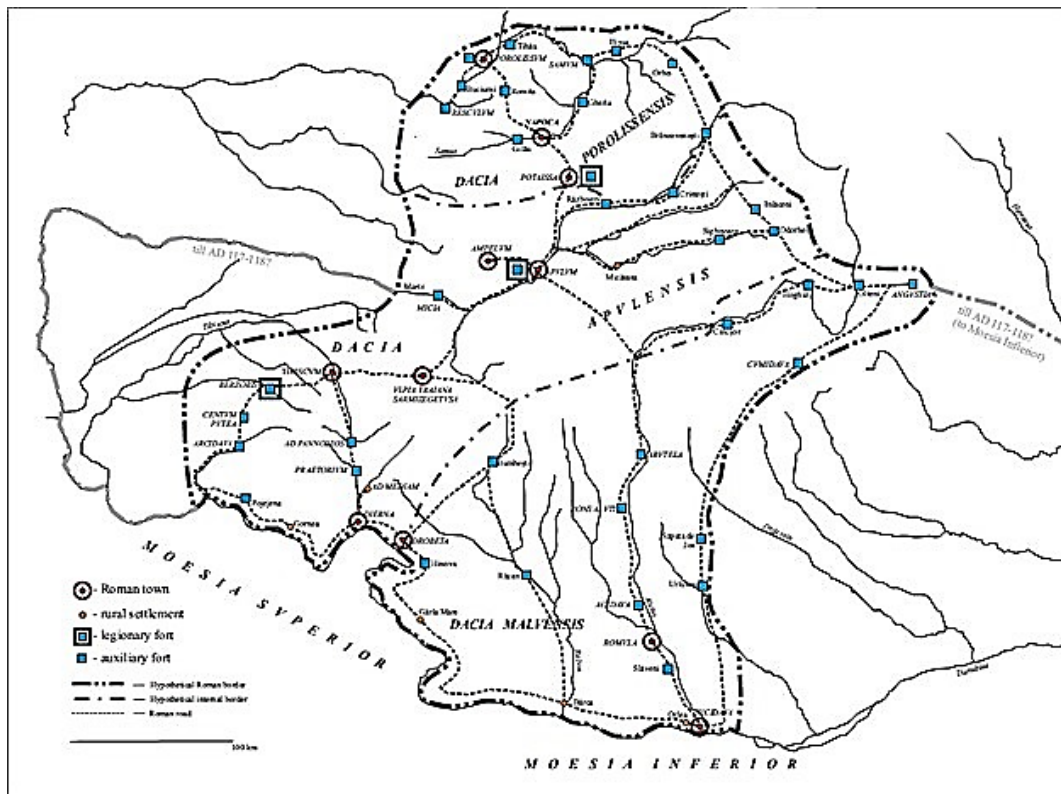


Fig. 1 – Map of Roman Dacia

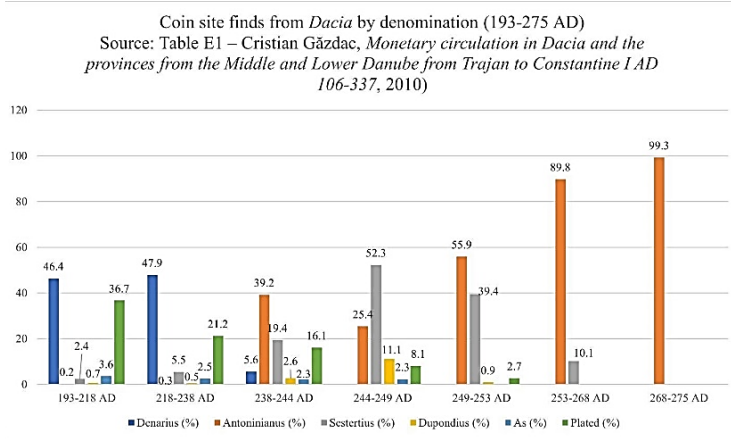


Fig. 2

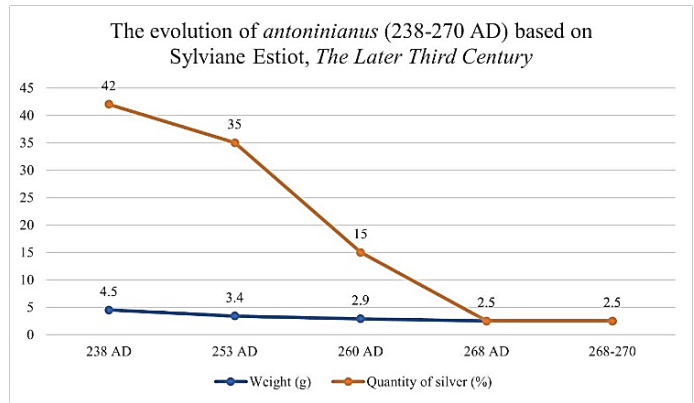


Fig. 3

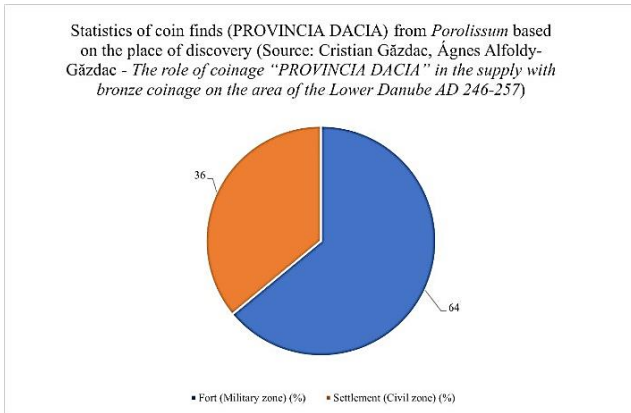


Fig. 4

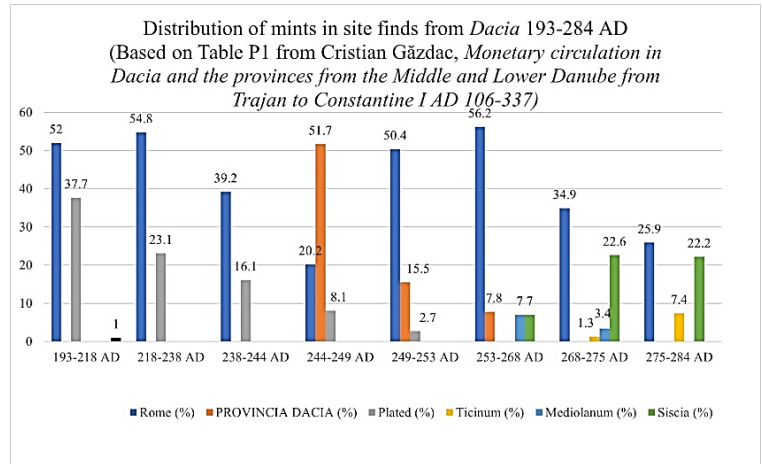


Fig. 5

The evolution of coin production of *Dacia* (246-257 AD)

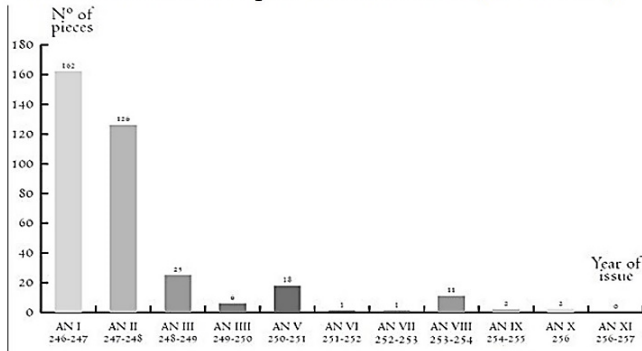


Fig. 6

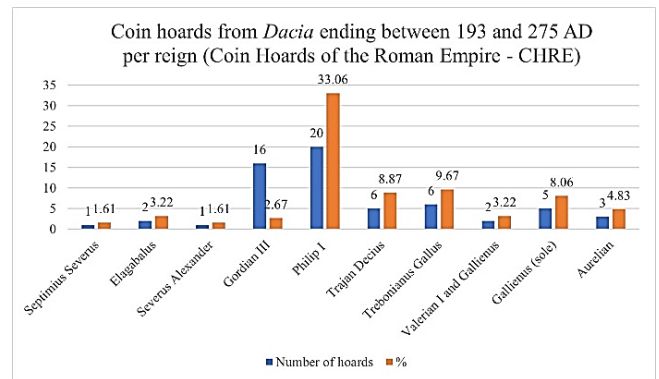


Fig. 7

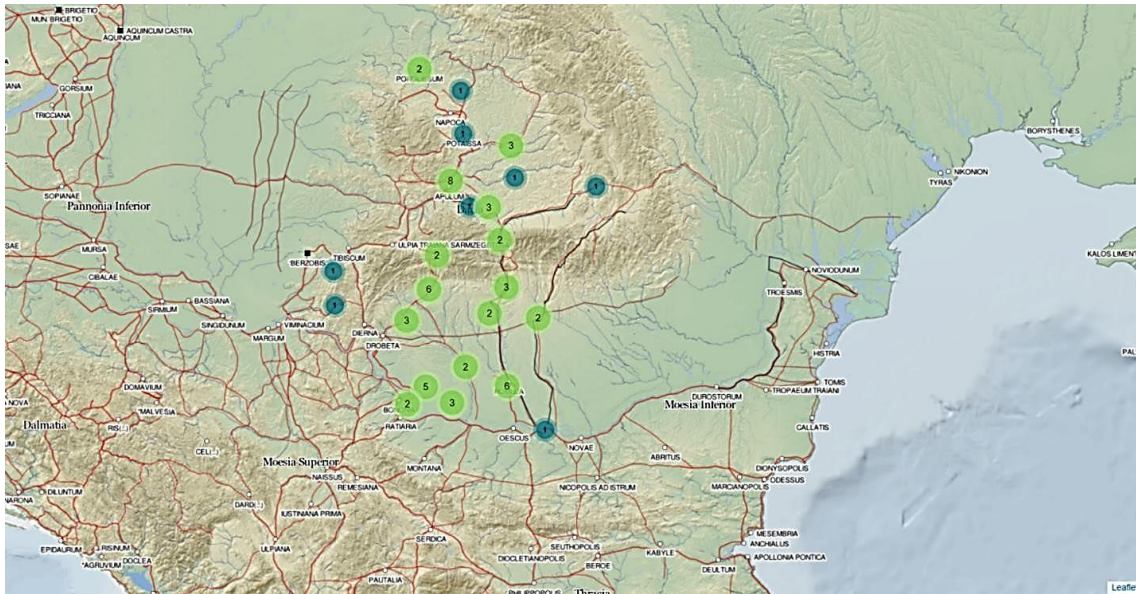


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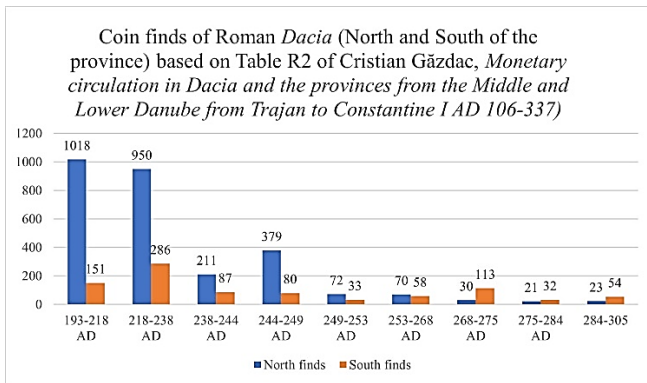


Fig. 9

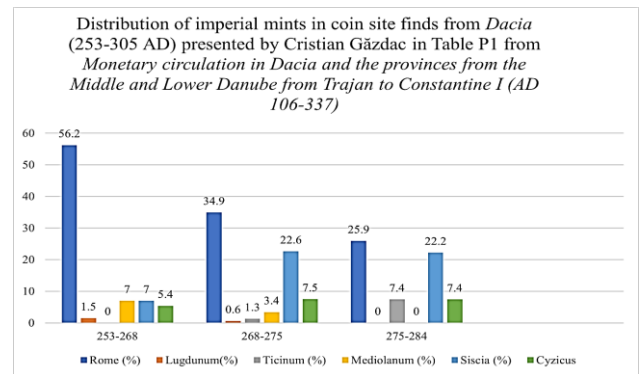


Fig. 10