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Summary of the Doctoral Thesis

The Exploitation of Vegetal Resources During the Gumelnița Culture on the Territory of Romania

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Key words: Gumelnița, carpology, archaeobotany, domestic plants, anthracology, seeds, charcoal, environment.

The subject of this paper fall within the archaeobotanical framework, specifically carpology. The archaeobotanical studies are based on the plant remains that are discovered in archaeological sites. Carpology, anthracology, palynology and other studies are grouped together in archaeobotany. They help in interpreting the relationships between humans and plants. Notably, the identified seeds and fruit can help elucidate the food preferences of human communities, the type of agricultural practices used and even climate change.

I. Research history

The study of plant remains had started during the 19th century with the analyses done on the Egyptian mummies and the submerged settlements in Switzerland (Wright, 2009; Pearsall, 1989, p. 4). In the interwar period, the archaeobotanical studies are developed in North America and followed by the ones made on the south-wester Asia material (Cârciumaru, Pleșa, Mărgărit, 2005, p. 39; Pearsall, 1989, p. 4). From the middle of the last century, archaeobotanical syntheses are developed (Hastorf, 2016; Zohary, Hopf, Weiss, 2012; Renfrew, 1973); all these analyses will have been collected and presented at the the first international congress (*International Workgroup for Palaeothnobotany*) from 1968 (Beneš *et al*., 2022, p. 62).

Anthracology, such as carpology, had a similar development due to their type of preservation and the complementary information. The optical light microscope used in the anthracological studies help improved wood analyses (Marguerie *et al*. 2010, p. 312). Starting with the last decades of the last century, different antharcological laboratories are developed. They will have help improve the analytical criteria (Kabukcu, Chabal, 2021; Asouti, 2006). All these studies will have been presented at the first *International Anthracology Meetings* (Montpellier, 1991) that brought together researchers specialised in anthracology (Badal *et al*., 2012).

In Romania, the archaobotnaical analyses are selective and rare in the second part of the 19th century. Regardless, up to the second part of the 20th century, most of these studies were either referencing ancient authors (Tocilescu, 1880), or they compared the local material with other studies form abroad (Nicolăescu-Plopșor, 1922). After that, carpological studies had stared to be presented from the point of view of archaeologists, specifically using artifacts that concluded the existence of agriculture in prehistoric times, but also the presence of seeds and fruits (Dumitrescu, 1966; Berciu, 1966, 1961; Nestor, 1951, etc.). The wood analyses are done earlier (Popovici, 1934), but they will not define a well-established domain.

The carpological studies were very succinctly made, most of them were collected in by E. Comșa (1987). The first carpological researcher was M. Cârciumaru, who begun his archaeobotanical research in the 1970s. Thanks to his studies abroad and the analysis of different carpological material, he will publish in 1996 the book „ Paleoetnobotanica" and it will become the first archaeobotanical monograph in Romania.

Other Romanian researchers are Felicia Monah; she studies and published many works based on the carpological material from the Moldavian region of Romania. She also published the first archaeobotanical monography of the archaeological site of Poduri-Dealul Ghindaru (Monah,

Monah, 2008). Beatrice Ciută is a carpology specialist focuses on the Transylvanian material, from prehistory to Medieval times.

Different archaeobotanical studies are published from the end of the 20th century thanks to the international research projects implemented. For instance, the Romanian French cooperation programme, developed by the National History Museum of Romania and the National History and Archaeology Museum of Romania from Constanța, together with the Ministry of Culture and Francophonie (France) and the Culture Ministry from Romania in 1993. New techniques and practices of archaeological research were put into work on the Eneolithic site of Hârșova, Constanța county (Randoin *et al*., 2025). Likewise, this project helped the scientific training of young interdisciplinary researchers. One of the were I. Tomescu whom became the first trained anthracological specialist from Romania (Tomescu, 2004).

II. General methodology

Both carpology, that studies the vegetal remains of the reproductive systems of plants that are preserved in archaeological sites and anthracology (the study of wood fragments from archaeological sites), are fields that can be included in a larger one called bioarchaeology (Marinval, 2010, p. 122; Tomescu, 2004, p. 15; Dincauze, 2000, p. 330-331). From a terminology aspect, the carpological studies had different names during its existence, from ethnobotany (the taxonomical study of plant remains and the relationships between plants and human communities), palaeoetnobotany (in which the archaeological aspect in the human-plant relationship is included) or palaeobotany (Lodwick, 2019; Ciută, 2008, p. 9-10). Even though in the English environment the term „archaeobotany" is used for this type of studies, in Romanian spaces, the term „carpology" is preferred; the firth one being an agglomeration of all filed that are based on plants found in archaeological sites. In general, carpology (or from now on, archaeobotany), and other fields based on different plant remains, have two types of interpretations: first one has an environmental point of view and the second one focuses on the human-plant relationship, from a human point of view (Wilkinson, Stevens, 2003, p. 15).

Methodological speaking, the collection of the material is the basis of the archaeobotanical and anthracological fields as well as the processing of soil samples. The preservation the botanical remains is due to different soil modifications that stops the decomposition (Cârciumaru, Pleșa și Mărgărit*,* 2005, p. 14; Dincauze, 2000, p. 331). The most frequent types of preservation are charring, mineralisation, waterlogged, drying or imprints. Charring is produced usually through natural of human-made combustion and it converts the biological chemical material into stable minerals. The macrobotanical remains with more woody tissues usually are better preserved through charring, such as wood fragments (Berinhuete-Azorín *et al.,* 2019; Marinval, 2010, p. 125; Ciută, 2009, p. 17; 2008, p. 16; Cârciumaru, Pleșa și Mărgărit*,* 2005, p. 15; Wilkinson, Stevens, 2003, p. 150; Dincauze, 2000, p. 334).

Mineralisation appears when the botanical tissue is changed with mineral substances or metallic oxides through precipitation. This type of preservation is more common in area with rich mineral rich soils, such as latrines, waste areas or near metal objects that are in contact with water (Marinval, 2010, p. 126; Cârciumaru, Pleșa și Mărgărit*,* 2005, p. 19; Wilkinson, Stevens, 2003, p. 159). Waterlogged material is found in wet anaerobe areas, like swamps or wells. Generally, waterlogged plants are preserved well, all organs and fragile parts can be found, such as petals. Drying also help in preserving all types of botanical material and it is based on either hot or cold environments (Marinval, 2010, p. 126; Wilkinson, Stevens, 2003, p 162-163; Cârciumaru, Pleșa și Mărgărit*,* 2005, p. 17; Dincauze, 2000, p. 334-335). An example of dried material is the archaeobotanical study made on the material from Tutankhamun's grave. Some of the species identified are onion (*Allium cepa*), garlic (*Allium sativum),* olives (*Olea europaea*) or fenugreek (*Trigonella foenum-graecum*) (Hamza, 2020).

Imprinting is commonly found, especially on ceramic made with chaff or adobe. The plant imprints are the negatives remains from the decomposed of plant remains. Most of these preservations are based on a type of human activity and their dating can be made based on the material that hold those types of imprints (Ciută, 2008, p. 18; Tomescu, 2004, p. 30-31).

The taxonomical determinations rely on the reproductive element of plants. The classification systems of life were developed since the ancient times. If, during the medieval age the plant morphology was the basis for the taxonomical classification, starting with the modern period, the classical binomial system is developed. Today, thanks to the molecular and DNA studies, a natural classification system is in place (Padial *et al.,* 2010; Anastasiu, 2008, p. 11; Woese *et al.,* 1990). The basic taxonomic unit is the species and following upwards there are the genus, family, order, class, phylum and kingdom. Also, the infraspecific classifications are used especially for the plant species with hereditary characteristics: subspecies, variety or form. For domestic plants, the intraspecific hierarchy is subspecies, convariety, variety and cultivar (Săvulescu, 2010, p. 8; Atanasiu, 2008, p. 24).

The scientific taxonomic nomenclature is presented in Latin; the binominal taxonomy is written in italic with the genus with capital letter. The biological name includes the authors initials and the years in which a specific plant received its name. The vernacular name of plant, generally, have a regional and historical value. Sometimes the plant names are used for many other species. That is why in this thesis the plant names will be followed by their scientific name (Rivera *et al.,* 2014). Another aspect that is important in taxonomic determination are the uncertainties that are written with *confer* (cf.) (Bengtson, 1988). All modern taxonomic changes are included in *The International Code of Nomenclature for algae, fungi, and plants.* This code is a series of regulation s and recommendations for scientific name utilisation (Turland *et al.,* 2018).

In the archaeobotanical analysis it is important to understand the botanical aspect of plants. Considering the fact that in this field, seeds and fruits are used, the correct identification of their formation is necessary. Plants that form seeds and fruits are grouped in the angiosperms and gymnosperms. Conifers develop naked seeds, and the angiosperms develop seeds that are surrounded by an ovary. Also, gymnosperms have grown woody species, with tracheid, unisexual flowers, needle-like foliage and so on. This phylum had dominated Earth since the Jurassic and Cretaceous age. After that, the Angiospermae dominated since 50 Myla (Benton *et al.,* 2022; De La Torre *et al*., 2020; Dörken, Nimsch 2019, p. 7).

Botanically, conifers reproduce through a female and male cone (strobili). The female one has a macrosporophyll ovule; the masculine cone has pollen bags. The bags have sporogenus tissue and they form the masculine gametophyte. The carpellary scales are the reproductive feminine elements that produces the ovules. Their pollination is anemophilous, and the fecundation is simple; it takes place in a year from the pollination. The seeds produce a single zygote, and it forms embryons, only one being fertilised. The seed is dry (Dörken, 2019, p. 8; Săvulescu, 2010, p. 33; Anastasiu, 2008, p. 154-157). The angiosperms have a complex fecundation process. The main characteristic of this phylum is the producing of flowers, different forms of leaves, vascular system etc. (Anastasiu, 2008, p. 169, Pearsall, 1989, p. 144).

The flower has a pedicel, receptacle, the floral coverage, androecium and gynoecium. The pedicel has the role to grip to the stem, the receptacle is the part that holds the floral elements and it is the terminal part of the pedicel; the floral coverage has a defence role and it can be of many types (simple, free, double); the androecium represents the totality of stamens and it is the male reproductive organ. The gynoecium is formed carpels. They hold the ovary and the pistil, found in the upper part (Săvulescu, 2009, p. 91-97).

The position of the ovary can be different. The hilum is the insertion point, and the chalaza is the division point of the tegument. The ovulum contains two integuments and it has a opening named micropyle. From here the male gametophyte falls for fertilisation. In the nucella there are three haploid cells (near micropyle) and another three antipode cells; a central cell (diploid) will go through the double fecundation process. The ovule is positioned in three ways (Săvulescu, 2009, p. 99).

Some of the macrobotanical remains found in archaeological sites are fruits: or more specifically parts of fruits, such as endocarp (the internal part of the fruit). Fruit contains epicarp, mesocarp and an endocarp; the epicarp is the external part, formed by the ovary epiderma; the mesocarp stores the reserve substances and is formed by the ovary parenchyma.

Fruits are classified in four classes: simple that can be dry or fleshy. Dry fruits can be hulled or naked. An example is common wheat caryopses (*Triticum aestivum)* which is a hulled dry and simple fruit. Other dry simple and hulled fruits are the achene (*Helianthus annuus* –sunflower), samara (*Fraxinus excelsior* – ash), lomenta, hulled silique (*Raphanus sativus* - radish), hulled silicule (*Cardaria draba* – whitetop).

Some of the dry simple naked fruits are follicle (*Consolida regalis* – forking larkspur), pods (*Lens culinaris* - lentil), silique (familia Brasicaceae), silicle (*Capsella bursa-pastoris* – shepherd's purse) (Săvulescu, 2009, p. 119-121).

Fleshy fruits can be hulled with small exceptions: berries has a fleshy pericarp and the epicarp, mesocarp and the endocarp thin (*Lycospersicon esculentum* – tomato), hesperidium have a spongy mesocarp (*Citrus reticulata* – mandarin), Melonie have the placental tissue fleshy and juicy (*Citrullus lanatus* – melon), pome has a cartilaginous endocarp (*Pyrus communis* -pear) and the stone fruit have a lignified endocarp (*Prunus avium* – cherry) (Săvulescu, 2009, p. 122-123). The fleshy naked fruits are partially naked drupe (*Juglans nigra* – walnut) and berries (*Ecballium elaterium* – squirting cucumber).

Multiple fruits are formed from a pluricarpels gynaeceum; they can be dry or fleshy (*Rubus idaeus* - rasbbery), the dry ones can be naked (poliachene – *Magnolia kobus* - magnolia) or hulled

(*Rosa canina* – brier; polisamara – *Liridendron tulipifera* - tulip). Aggregaste fruits are mulbbery (*Morus alba*) or fig (*Ficus carica*) (Săvulescu, 2009, p. 124).

Seeds are the reproductive structure of a plant from the angiosperm phylum, and they are protected by carpels. A seed contains: embryo, endosperm, seed coat (Săvulescu, 2009, p. 112; Pearsall, 1989, p. 144). The seed coat protects the seed for external factors; it is formed from testa (external part) and tegmen (it hods water inside). Charring usually destroys the seed coat (anatomic element for taxonomic identification) (Mikić *et al.,* 2015). From the embryo the future plant is developed and it contains radicle, hypocotyl, epicotyl and plumule (Săvulescu, 2009, p. 115). The Endosperm stores the nutrients for the future plant (Săvulescu, 2009, p. 117).

Other seed parts: hilum (the disarticulation from the fruit scar), micropyl (pore with the least resistance for the radicle to puncture), rafa (o longitudinal depression found on anthropic seeds) and chalaza (Săvulescu, 2009, p. 113-114).

Most of the macrobotanical remains are hard to discover in archaeological sites and that is why soil samples are collected. Some remains can be collected manually when a bulk agglomeration is found. Unfortunately, the direct collection does not help in the exhaustive interpretation due to the singular processes that formed a specific agglomeration (Pearsall, 1989, p. 16). Most of the time, collecting of soil sample is necessary and it can be systematic or direct. The main benefit of collecting of soil sample is the collection of the potential information spatially and temporally placed in a specific archaeological site. The direct collection can be used in very visible features or context that are disperse. The compositional collection helps selecting an area for an objective collection of soil (Ciută, 2008, p. 24; Pearsall, 1989, p. 97). Another type of systematic sample collection is in a collum, that helps in a better subsample collection. Unfortunately, it does not reflect the randomly dispersion of seeds and fruits (Pearsall, 1989, p. 98). The selection of a sample depends on the volume of a sample, the importance of a feature (archaeologists and other specialists can define the importance of a specific area). The volume can be the minimum 20 litre to 30 litres. The density can be calculated to identify the ideal volume for a sample in a given area/feature/archaeological site (Pearsall, 1989, p. 101).

The processing of samples can be made through dry sieving, wet sieving or flotation. Dry sieving can be used for samples with dry, sandy soils or when the sample itself contains mainly archaeobotanical or anthracological remains (Wilkinson, Stevens, 2003, p. 156). In wet sieving it is used a column of sieves with different apertures, thus different types of material are collected in their respective class dimensions. Normally, the soil sample is put on the supper sieve and after that it is washed. This type of sample processing can be used for waterlogged samples; it separates the soil from the artefacts and ecofacts but there is a possibility of eliminating archaeological material if the water input is too strong (Ciută, 2008, p. 57). Flotation is used mainly for catching the archaeobotanical remains. This process allows to recover all types of archaeological remains. Usually during flotation a soil sample is emerged in a body of water and after that the water influx is flushed from below, thus helping in the mixing of water with the soil (Ciută, 2008, p. 39; Tomescu, 2004, p. 71; Wilkinson și Stevens, 2003, p. 154; Pearsall, 1989, p. 19).Flotation can be manual or mechanical and it can be used inside or outside, depending of the water source. Manual flotation helps with a better human control (Pearsall, 1989, p. 40). Mechanical flotation helps in a better separation of the soil from the archaeological material; it necessitates electrical power, at least one barrel to hold the sample and collect the heavy fraction and a external sieve for collective the light fraction (Pearsall, 1989, p. 20). A mechanical flotation machine was implemented in 1969 and used for the archaeological research in south-western Asia. Other type of mechanical flotation machines was used, depending on environmental factors, financial sources and time. (Pearsall, 1989, p. 28).

After processing, the material needs to dry out, preferably in shady and dry, and after that they are sorted. Sorting is done manually; it is a subjective process and long lasting. Depending on the necessities of a specific archaeological site, a sample can be partially or completely sorted (Ciută, 2008, p. 51-52; Pearsall, 1989, p. 47, 50-51). The ecofacts and artefacts resulted from this process are kept deperstly for a future analysis.

In the Archaeological Institute „Vasile Pârvan", the soil processing can differ; the labelling of material is made with the archaeological data and the processing used. Samples are quantified by volume. The sieves are decontaminated before using them. The flotation machine was made after the specificities of the Ankara model but without the chemical processing. The barrel has a volume of 200 de litres, and the water source is the sewage system of the Casa Oamenilor de Știință; two sieves are introduced in the barrel, with another one held on the exterior for the collecting of the light fraction.

The extracted wood is separated based on different dimensions, using sieves; or they are separated in four parts in case of a rich sample. The sorting is made under a stereomicroscope or a magnification lamp. All archaeological material is kept, but in different containers (ceramic fragment, lithics, charcoal, seeds etc.).

The identification of the archaeobotanical remains is made considering the botanical knowledge presented above. The morphological differences that are produces by the preservation processes can influence the determination: that is why botanical atlases, reference collections or other publications are used. The morphological descriptions are important, and they are scribed in tables used for this step. For instance, charring can destroy the surfaces of macrobotanicasl remains or other anatomical element (testa, embryo), all depending on the combustion temperature (Berinhuete-Azorín *et al.,* 2019). Fortunately, many anatomical elements are preserved and can be used: the position or the form of the embryo, general dimensions of the fruit and seeds. For examples the transversal channels on the hazelnut endocarp (*Corylus avellana*) are indicative element in identifying this species (Schoch, Pawlik, Schweingruber, 1988, p. 65).

For the viability of a sample, the quantifying the macrobotanical remains is important. This calculation can be done in different ways: by utilising the minimum number of individual principle (MNI) or by quantifying the number of macrobotanical remains. The MNI in archaeobotany can be a whole seed, fruit or even a plant. The calculations are diverse, the one applied here is based on Hillman *et al.* (1996) and Pradat (2015). Considering that most of the macrobotanical remains are mostly domestic plant species, other part of the plat such as chaff do help in the taxonomic determinations. Although small, they contain many more characteristics that helps in pinpointing more precisely a given species.

As I mentioned, the reference collections boost the plant identifications, especially if there are both archaeological and modern pant species. Drawing macrobotanical remains also helps; the illustrations can help focus on different plant parts that usually are not found or are too small to observe without a microscope. It must be said that illustrating can be a subjective process, and an anatomical element can differ from one illustration from another (Goddard, Nesbitt, 1997).

The archaeological interpretation of the macrobotanical remains depends on the quantification and the existing archaeological data. The qualitative and quantitative analyses help in developing the taxonomical plant lists, in comprehending the plant utilisation by human communities, the agricultural practises used. For instance, the calculation of ubiquity from a specific sample, or feature or archaeological site can be used (Diehl, 2017). Another type of statistical analysis that can be use is the Correspondance Analysis that allows to show in a more accessible way the archaeobotanical data.

Archaeological features are the first that help in interpreting the archaeobotanical data. Most of the macrobotanical remains are found charred, usually near hearts, dwellings, in waste area etc. Connecting the archaeological data with the type of the botanical remain found (charcoal, fruit, chaff) we can understand the motive in the utilising a specific species. Such as, the chaff found in a hearth can pinpoint the utilisation as a source for combustion. Food can also be an interpretation, especially if fruit or seeds fragment are found in a hearth, even in an amorphous state (Valamoti *et al.,* 2021). Also, the chaff and fragment of cereals can indicate the type of crop processing used (Wilkinson, Stevens, 2003, p. 195). For instance, some wild weeds mimic the growing pattern of domestic plants, also by identifying the weed species we can suggest what kind of harvesting was done, uprooting or cutting. Another example is the multiple stages needed to process the hulled wheat in order to clean away the unwanted parts (lemma, palea) through winnowing, threshing, sieving etc.

For anthracology, the first steps involving the sample processing, sorting are very similar to the ones used for archaeobotany. This field helps in adding more information regarding climatic changes, plant economy, reconstruction of forest ecosystem. Wood is the basis of all anthracological analysis. Anatomically, wood is a conducting tissue, and it held the trunk in a upright position. Morphological elements used in the taxonomic identification are wood vessels, tracheids, perforations etc. (Chabal *et al*., 2010). The main results of the antrachological identifications are palaeoethnographical (wood used in human activities), palaeoethnobotanical (human – environmental interactions and their results), palaeofloristical (taxonomical identification) and palaeocological (changes in forest population in time) (Tomescu, 2004, p. 15). The main objectives are the comprehension of the purpose of wood utilisation through specialised activities (construction, cultural activities) or unspecialised activities (domestic activities) or through highlighting the palaeoeconomical or palaeobotanical interest. For example, wood framgents collected form dispersed deposits and that reflect an unspecialised activity can suggests a long utilisation of that feature and also it can influence the taxonomic list and even th evolution of wood species in time (Kabukcu, Chabal, 2021; Tomescu, 2004, p. 51-53).

As I mentioned, wood identification for archaeological sites is similar to the archaeobotanical ones, specifically by the sample collection, the sample processing and their sorting. Also, wood fragments are preserved through charring, waterlogging or drying. The anatomical elements are identified with a microscope through breaking the fragment in transversal, longitudinal tangential or longitudinal radial parts. The wood quantification can be made in multiple ways: through counting, through weighing or through separating the fragments by their size. If a sample is rich in wood fragments, then only the bigger ones can be identified or randomly (Chabal *et al.,* 2010, p. 56; Tomescu, 2004, p. 82-83; Schweingruber, 1978, p. 13). The fragmentation is accidental, the process is not impacted by the wood morphology or by the plant species but can be influenced by the type of storage of post-depositional factors. The frequency of a taxon will be visible in any subsampling based on size (Kabukcu, Chabal, 2021).

For an optimal wood identification, a minimum of 100 fragments or even more is necessary for the viability of a sample. The taxonomic data is represented with a redundancy curve that establishes the taxonomic potential of a sample (Kabukcu, Chabal, 2021). The redundancy curve can identify the spatial distribution of wood taxons in a given archaeological site. A anthracological spectrum is realised with the taxonomic lists and show the distribution in time of the wood species identified. An anthracological diagram is made from a set of spectra that helps improve the wood distribution chronologically. The archaeological interpretation is very important, if the samples were collected form a hearth of a pole pit, then those samples have a palaethnobotanical value due to their limited functionality (Tomescu, 2004, p. 52-55). Specialised deposits (ceramic firing kilns) for instance can identify palaeoetnobotanical and palaeoethnografical informations.

III. Considerations regarding the cultural and the environmental aspects of the studies area

To comprehend the temporal context, it is essential to identify the population movement that influenced the emergence of Gumelnița culture. The neolithisation of the northern lower Danube River catchment area takes place during the 7th millennium BC when Anatolian populations travel through the Balkan rivel valley together with new technologies and knowledge (Mattila *et al*., 2023; Chapman, 2014). During the following millennium, cultural changes are observed that eventually bring about the development of true late neolithic and Eneolithic cultures, such as Boian and later Gumelnița, the latter being part of the cultural archaeological complex Kodjadermen-Gumelnița-Karanovo VI.

Historycally, the Gumelnița culture was first observed in the interwar period, when much archaeological research were underway in southern Romania, especially at Sultana and Gumelnița (Nestor, 1928; Andrieșescu, 1924; Dumitrescu, 1924). Subsequently, the main characteristics of the material culture were defined by other research at Glina or Vidra (Dumitrescu, 1934; Rosetti, 1934). In the second part of the 20th century, the continuation of archaeological researches had begun, and after the fall of the communism period, many international projects helped in diversifying these investigations (Randoin *et al*., 2025; Mills, Trick, 2001). The division in phases of this culture was created Gumelnița culture from the very beginning of its identification. This relative chronology (with three phases) it is still in use, even though more and more C^{14} analyses are helping in understanding the evolution of this material culture (Frînculeasa, 2016).

Chronologically, Gumelnița was culturally influenced by previous traditions, mostly originated from the Boian-Maritsa-Polianitsa cultural horizon. Gumelnița expanded from centre Muntenia to Dobruja region in east, south-east nowadays Republique of Moldavia, north-east Moldavian region to the norther-eastern part of the Aegean Sea. The previous Boian culture was also identified at the beginning of the last century, and its name comes from the formed Boian Lake form the south-easter part of Romania. This culture is also separated in four cultural phases, (Comșa, 1987) and the main material culture characteristics are the geometrical ceramic motifs, initially sporadic flat settlements that grew into tell settlements, with rectangular dwellings an so on (Opriș *et al.,* 2022). At the middle of the 5th millennium BC there is a growth in0 the human population that is connected to extension of tell settlements. This development is identified with Gumelnița culture. Thought, the decline is rapid only a few centres remain at the beginning of the 4th millennium BC (García-Vázquez *et al.,* 2023; Popescu *et al*., 2023). The Gumelnița material culture evolves naturally from the Boian base, continuing with the rectangular dwellings, necropolis, demarcation of living spaces, the onset of metallurgical works etc. (Marinescu-Bîlcu, 2001). The Stoicani-Aldeni cultural aspect in a local manifestation of Gumelnița culture, localised in north-eastern part of Muntenia and with spreading to southern Moldavian region and south-easter Republique of Moldavia (Ștefan, 2023, p. 251).

The Romanian Plane formation takes place during the Quaternary period and was based on the sediment filling of the former Pleistocene Lake, the tectonic activities and the irregular subaerial (Posea, 2002, p. 288-289). The Plain inclination is north-south and south-east with Nordic plateaus and deep fragmentations; the eastern part (Bărăgan Plain) has a alluvial lowland aspect (Popescu, Ielenicz, 1983, p. 159). The Romanian Plain evolution is closely tied to the Danube River flow. The river influenced its high terrace formation and also its tributaries (Posea, 2002, p. 291-292). The main soils found in the Romanian Plain are developed on the loess and they are: cambisols, chernozem, brown soils etc. (Badea, Alexandru, 1983, p. 644-646). The recent vegetation is steppic or forest-steppic. Oak forests develop mainly in. The forest-steppe is represented by Mixed oak forests with wild pastures and other fruits bearing trees and shrubs (pears, hawthorn, lime). In the Danube floodplain human grown forest exists to protect the agricultural lands from floods (Badea, Alexandru, 1983, p. 646-647).

The Gumelnița culture developed during the Atlantic period, a phase of warm and wet climatic event. This periodisation system was developed on the fossils found in the Scandinavian Peninsula. Corroborated the periodisation with his studies on pollen deposits in the Carpathian Mountains and resulted a forest population evolution during the Ace Age period onward (Cârciumaru, 1996, p. 18-19). In middle Holocene, The Romanian Plain is charactered by a dense forest, visible on both sides of the Danube River. The main species found were oak, hornbeam, elm, ash, alder and lime tree. The climatic oscillations are suggested by the appearance of humid or riparian plant species that indicates a rise in atmospheric humidity (phenomenon that characterises the optimal climatic period) and the advent of Oriental hornbeam and black hornbeam indicate a submediterranean climate (Filipova-Marinova, Pavlov, Slavova*,* 2024; Hanganu *et al.,* 2023). The forest extension begins to decrease, which is apparent especially since the second part of Holocene period, when the pollen of plant indicative to anthropological activity rises (Hanganu *et al.,* 2025, 2023).

Concerning the animal resources, during the 5th millennium BC, human populations depended mainly on domestic species. For instance, bovines are most used during Boian culture, with some exceptions when ovicaprids surpasses bovines. Cattle are used mainly for meat but also for their secondary products (Bălășescu, Radu, Moise, 2005, p. 204). In some cases, the caloric intake is maintained by other species, such as fish and mollusc, especially in settlements near water sources. Other animal species identified are pig (the third most important species) and dogs (small importance but with proof of human consumption) (Bălășescu, Radu, Moise, 2005, p. 203). Hunting was visible with remains of red deer, roe deer, wild boar. For Gumelnița culture, domestic animals continue to be preferred, especially bovine, ovicaprids and pigs. Evidently, the percentage varies form settlement to settlement. Other species used are aquatic ones, such as molluscs but also fish (catfish, pike, carp etc.) (Lazăr *et al*., 2020, 2017). Dogs continue to be grown as a food resource. The importance of pigs is growing also. In the latter part of Gumelnița culture, hunting appears to become more important but does not surpass other domestic species. Red deer is one of the most hunted species, followed by wild horse (Bălășescu, Radu, Moise, 2005, p. 205-221).

For the Stoicani-Aldeni cultural aspect, although with little archaeozoological studies, some lines can be drawn bovines are the most important, followed by ovicaprid and pigs. Hunting does not seem to be of high value (Bălășescu, Radu, Moise, 2005, p. 210).

IV. Published and unpublished raw archaeobotanical data

Form the total of 29 archaeological sites with archaeobotanical data, 18 have data from the Gumelnița culture, three have data from the Stoicani-Aldeni cultural aspect, nine have data for the Boian culture and two for the Cernavodă culture. From the total 29 sites, eight have unpublished data, Other botanical data presented here are the anthracological, palynological and fitolite and archaeological descriptions and radiocarbon dates (where there are). The primary statistical data (procentage) are presented here both using the raw data and the MNI. As such, the first site is Aldeni-*Gurguiul Balaurului* (Buzău county) with published data and which is attributed to the Stoicani-Aldeni aspect. The archaeobotanical material was found in a ceramic vessel with domestic cereals (Cerealia) being the most abundant, followed by barley. Brăilița (jud. Brăila) is the next site presented with three samples: two were collected from graves and one from a Gumelnița pit. From the Gumelnița pit: emmer (*T. dicoccum*) is the most abundant followed by club wheat (*T. compactum*). Other species found: Timofeev wheat (*T. timopheevii*), rye (*Secale cereale*), barley (*Hordeum* sp.), einkorn (*T. monococcum*), spelt wheat (*T. spelta*) and common wheat (*T. aestivum*).

At Bordușani (Ialomița county) many achareobotanical studies were done. Th first published one shows a bulk bitter vetch (*Vicia ervilia*) assemblage from a Gumelnița ceramic pot. Other archaeobotanical studies were made on differet samples collected from Gumelnița dwellings. Einkorn is the most abundant, followed by domestic cereals (Cerealia) and barley (naked and hulled). Other species are emmer, spelt wheat, lentil, peas, bitter vetch, common knotgrass (*Polyonum* cf. *aviculare*), green foxtail (*Setaria* cf. *viridis*), elderberry (*Sambucus nigra*) etc. (Popovici *et al*. 2014, p. 100-102). Bordușani also has an anthracological study that revealed that these communities used oak (*Quercus* sp.) and, poplar/willow (*Populus-Salix* sp.) wood for construction. The species used for fuel are poplar/willow, elm (*Ulmus* sp.), cornelian cherry

(*Cornus* sp.), wild grape (*Vitis sylvestris*) and oak (Tomescu, 2003, p. 83). Likewise, another unpublished archaeobotanical analysis was made, the sample was collected from a Gumelnița passageway. Domestic cereals are the most abundant followed by barley, specifically naked barley. Other species are einkorn, hulled barley, spelt wheat and other.

Căscioarele-*Ostrovel* (Călărași county) is represented by two samples, one of which has charred material the other with modern material, both samples were collected from a dwelling. The charred species identified are bitter vetch, hairy vetch (*Vicia hirsuta*), common knotgrass, wild peas (*P. elatius*), wheat and barley (Cârciumaru, 1996, p. 69). From Geangoești-*Hulă* (Dâmbovița country), from all samples analysed, only three were published. The first one had exclusively naked barley grains and the second contained emmer, both samples were extracted from ceramic vessels from a Gumelnița dwelling (Cârciumaru, 1996, p. 78). The third samples, also from a ceramic vessel, had a few peas seed and emmer grains (Ilie, Cârciumaru, 2021). The rest of the samples were collected from various features, such as dwellings, ceramic pots, archaeobotanical accumulations, occupational layers stratigraphical units etc., all being attributed to Gumelnița culture. From all the 10 samples, emmer appears, to be the most well represented followed by wheat (*Triticum* sp.) and domestic cereal. Naked barley is also well represented. Other specie s found einkorn, spelt wheat, club wheat, Timofeev wheat, lentil and peas. From the gathered group plum genus (*Prunus* sp.) is best represented, followed by scratch bedstraw (*Galium aparine*), common dogwood (*Cornus* cf. *sanguinea*), false cleavers (*Galium spurium*), blackberry (*Rubus* cf. *fruticosus*), water pepper (*Persicaria hydropiper*), bromes (*Bromus* sp.) etc.

The Gherăseni-*Măgura Cremenea* (Buzău county) archaeological site is represented in this thesis by an unpublished sample, attributive to Gumelnița culture. Naked barley is the best represented species. Other species found are bitter vetch and oat (*Avena* sp./cf. *sativa*). A second sample was given but it contained only modern seeds and fruits. The next archaeological site is Grădiștea Ulmilor – Vărăști (Călărași county) with two samples published: one was collected from an occupational Boian layer and the other form a Gumelnița layer. The first one had about 100 grams of material whit naked barley being the most abundant, followed by emmer and einkorn. The second sample had only barley (Cârciumaru, 1996, p. 83).

The Gumelnița site had a multitude of botanical analyses made. The first archaeobotanical study published had a sample collected form a Gumelnița layer and contained only naked barley. (Cârciumaru, 1996, p. 83). Other archaeobotanical data were done on different Gumelnița features. Some plant species identified are einkorn, barley, peas, bitter vetch, oak, common knotgrass, elderberry, grape, cherry plum (*Prunus cerasifera*) ș.a. Another published study is the fitolite one that inferred the existence and utilisation of cereals species (Lazăr *et al.,* 2017, p. 140-142). Other samples published were collected from the terrasse; some graves and other features from Gumelnița culture were analyses, together with Boian and Cernavodă feature. The Gumenița one contained a few archaeobotanical remains, mainly of domestic cereals, barley, wheat, einkorn, peas etc. The Boian feature had mainly naked barley, fat hen (*Chenopodium album*), einkorn, spelt wheat, bitter vetch etc. The Cernavodă material is rare, with only wild cereals and fat hen (Lazăr *et al*., 2020). The unpublished material was collected from the tell and the terrasse and it has a large diversity. Some of the identified species are einkorn, hulled barley, Timofeev wheat, bitter vetch, peas, emmer, club wheat, plum genus, blackthorn, common knotgrass etc.

Othe botanical analyses that were realised are the anthracological and isotopically ones. The wood identification showed a taxonomic diversity, where elm had de largest quantity, followed by ash, oak, poplar/willow etc. The isotopic analysis had shed light into the diversity of food source used by the Gumelnița community and thus results the resilience of these people; also it appears that some of the domestic plants benefited from manuring (García-Vázquez *et al.,* 2023).

The Hârșova tell (Constanța county), has archaeobotanical data published: the first were made on Boian culture material with a large diversity: einkorn, spelt wheat, wild emmer (*Triticum* cf. *dicoccoides*), emmer, lentil, peas, Timofeev wheat and others (Hovsepyan, Buxó, Popovici, 2020, p. 305-319; Cârciumaru, 1996, p. 85-86). The samples collected from Gumelnița features contained similar plant species to the Boian samples: einkorn, naked barley, bitter vetch, elderberry, tatarican colewort (*Crambe tataria*), grape, clover (*Trifolium* sp.) etc. (Hovsepyan, Buxó, Popovici, 2020, p. 305-319; Monah, 2007). Finally, a few Cernavodă features had samples collected that resulted in few macrobotanical remains with common wheat being the best represented species. Other studies made are pthe palynological one that showed a large taxon diversity: wild cereals, willow (*Salix* sp.), mugwort (*Artemisia* sp.), fir (*Abies* sp.), pine (*Pinus* sp.) etc. (Tomescu, 2005).

From Ipotești (Olt County), the Boian archaeobotanical material was comprised of peas, einkorn and emmer (Cârciumaru, 1996, p. 86). Issacea-*Suhat* (Tulcea C4ounty) had many samples collected from Boian features and they contained fragments of cornelian cherry (*Cornus mas*), einkorn and emmer (Monah, 2005). The Isvoarele site (Giurgiu County) is presented here with two Boian samples that had doestic cerelas, barley, bitter vetch and einkorn (Cârciumaru, 1996, p. 89). The next archaeological site is Lăceni (Teleorman County) with Gumelnița macrobotanical remains. The taxonomic list consists of einkorn, barley, fat hen, black nightshade (*Solanum nigrum*) and so on (Bogaard, 2001).

Lișcoteanca-Movila Olarului (Brăila County) has a published archaeobotanical study of Gumelnița origin that shows the existence of emmer, common wheat and einkorn (Cârciumaru, 1996, p. 90). From Luncavița (Tulcea County) only fragment of cornelian cherry was found. From Mavrodin-*Pod* (Teleorman County) only fat hen was identified.

Although Măgura Cunești (Călărași County) and Morteni (Dâmbovița County) had macrobotanical samples attributed to Gumelnița culture that were published, later radiocarbon analysis showed that these samples were of later origin, specifically from the medieval period and from Iron Age period, respectively (García-Vázquez *et al*., 2025; Golea *et al.,* 2023).

Mălăieștii de Jos (Prahova County) has a small deposit of elderberry published. Thgis material is attributed to Stoicani-Aldeni cultural aspect (Frînculeasa, 2009). Also, Mănăstioara (Vrancea County), a Stoicani-Aldeni site, has archaeobotanical sample published with rye (*Secale cereale*), barley, corncockle (*Agrostemma githago)* and so on (Monah, 2007, p. 333-342). The Pietrele tell (Giurgiu County) has a few botanical data published. The archaeobotanical study showed that the plant species identified are mainly of gathered specifies wild grapes, cornelian cherry, common hawthorn (*Crataegus monogyna*), belladonna (*Atropa bella-donna*), but also barley and einkorn (Toderaș *et al*., 2009, p. 56-59). A pollen analysis showed the existence of a forest-steppe environment with oak, lime tree (*Tilia* sp.), European hornbeam (*Carpinus betulus*), hazel shrubs, beech (*Fagus* sp.), elm etc. (Hansen *et al*., 2012, p. 11-12).

The Radovanu-*La Muscalu* (Călărași County) archaeological site has a few botanical data published. For instance, some oak fragments were analysed, also the pollen study showed the existence of an environment consisting of oak, lime trees, elm, cereals (Gramineae) and nettle pollen (*Urtica* sp.) that indicate a human presence in the area. The published and unpublished archaeobotanical study were made on Boian and Gumelnița material. Emmer, einkorn, Timofeev wheat and elderberry were found (Cârciumaru, 1996, p. 112). The next site presented is Seciu- *La Pompieri* (Prahova County) with a wheat impression on a ceramic fragment attributed to the Stoicani-Aldeni cultural aspect (Cârciumaru, 1996, p.114). Sultana-*Malu Roșu* (Călărași County) is represented here by samples collected from Gumelnița features where the most abundant species is fat hen, hazelnut, dog rose (*Rosa canina*) and field gromwell (*Buglossoides arvensis*), wheat, barley, emmer and other. New anthracological studies reveals a forest-steppe environment with mixt oak, hornbeam, lime tree and fruit trees (Müller *et al.*,2025; Golea, Stravrescu-Bedivan, Lazăr, 2014). Taraschina (Tulcea County) has few botanical studies, one of which is the fitolite analysis that suggests the existence of cereal crops and the archaeobotanical analysis that resulted species naked barley, emmer, einkorn and cornelian cherry (Danu *et al.,* 2018).

The Teiu (Argeș County) archaeological site has both published and unpublished data that shows the utilisation of barley, einkorn, emmer and other species. Ulmeni (Călărași County) is represented here by a purple gromwell seed (*Buglossoides purpurocaerulea*) attributed to Gumelnița culture (Cârciumaru, 1996, p 119-122). The Vitănești (Teleorman County) archaeological site has a few samples collected and processed; where barley is the most numerous species found (Bogaard, 2001). Vlădiceasca-*Ghergălăul Mare* (Călărași County) has some botanical studies published, such as the pollen analysis which indicates the presence of cereals and a weak presence of forests, but with a strong antropization signal. The archaeobotanical analyses were made on both Boian and Gumelnița material that consistns in einkorn, emmer, barley, bitter vetch and other (Cârciumaru, 1996, p. 126-127).

This chapter ends with a comparison between the plant usage between the northern and southern parts of the Danube River that shows a resemble of domestic plants usage with few exceptions.

V. Statistical analysis and data interpretation

This chapter presents the different types of statistical analyses used on the data presented in the previous chapter, with all the modifications and selections made for the calculations. The applied systems are presented, the motivation behind these choices and the calculations After that, using the calculation a synthetic interpretation of the archaeobotanical data is made, regarding the evolution of food choices and wild and domestic plant usage in the 5th millennium BC.

VI. Biological, ecological and archaeological data of the identified plant species

This chapter is a general alphabetical plant representation. All the families, genus and species found in the sites presented in the chapter IV (Published and unpublished raw archaeobotanical data**)** are inscribed here. In total 30 plant families and 120 genus and species were odentified. Some of these plants also have their medicinal properties and thus presented here. The chapter also contains a general description of the plant domestication from south-easter Asia. This area is home to most of the domesticate presented in this thesis. I also included the domestication markers, the differences between the domestic species and their ancestors and the theories behind the domestication distribution through Europe, specifically the Balkans.

VII. Discussions and conclusions

This final chapter is an accumulation and a synthetisation of all the material and interpretations presented above. I enlisted the main inputs I reached during this PhD programme: the new taxonomic identifications, the news species that are unique (for now) in Eneolithic south-eastern Romania. I specified the importance in sample collection and the processing of them. As well, I emphasise the importance of taxonomic re-identification of old material to bring to light the existence of possible new species.

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