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ABBREVIATIONS

ActaArchHung	Acta Archaeologica Academiae Scientiarum Hungaricae (Budapest)
ActaEthnHung	Acta Ethnographica Academiae Scientiarum Hungaricae (Budapest)
ActaOrHung	Acta Orientalia Academiae Scientiarum Hungaricae (Budapest)
ActaMusPapensis	Acta Musei Papensis. A Pápai Múzeum Értesítője (Pápa)
Agria	Agria. Az Egri Múzeum Évkönyve (Eger)
AH	Archaeologia Historica (Brno)
AHN	Acta Historica Neolosiensia (Banská Bystrica)
AJMK	Arany János Múzeum Közleményei (Nagykőrös)
AKorr	Archäologisches Korrespondenzblatt (Mainz)
Alba Regia	Alba Regia. Annales Musei Stephani Regis (Székesfehérvár)
AnalCis	Analecta Cisterciensia (Roma)
AnnHN	Annales Historico-Naturales Musei Nationalis Hungarici (Budapest)
Antaeus	Antaeus. Communicationes ex Instituto Archaeologico (Budapest)
Antiquity	Antiquity. A Review of World Archaeology (Durham)
AR	Archeologické Rozhledy (Praha)
ArchA	Archaeologia Austriaca (Wien)
ArchÉrt	Archaeologiai Értesítő (Budapest)
ArchHung	Archaeologia Hungarica (Budapest)
ArchLit	Archaeologia Lituana (Vilnius)
ArhSof	Археология. Орган на Националния археологически институт с музей – БАН (Sofia)
ARR	Arheološki Radovi i Rasprave (Zagreb)
Arrabona	Arrabona. A Győri Xantus János Múzeum Évkönyve (Győr)
AV	Arheološki Vestnik (Ljubljana)
Balcanoslavica	Balcanoslavica (Prilep)
BÁMÉ	A Béri Balogh Ádám Múzeum Évkönyve (Szekszárd)
BAR	British Archaeological Reports (Oxford)
BMÖ	Beiträge zur Mittelalterarchäologie in Österreich (Wien)
BudRég	Budapest Régiségei (Budapest)
Castrum	Castrum. A Castrum Bene Egyesület folyóirata (Budapest)
CommArchHung	Communicationes Archaeologicae Hungariae (Budapest)
Cumania	Cumania. A Bács-Kiskun Megyei Múzeumok Közleményei (Kecskemét)
DBW	Denkmalpflege Baden-Württemberg (Stuttgart)
EMÉ	Az Egri Múzeum Évkönyve (Eger)
EurAnt	Eurasia Antiqua. Zeitschrift für Archäologie Eurasiens (Bonn)
FolArch	Folia Archaeologica (Budapest)
FontArchHung	Fontes Archaeologici Hungariae (Budapest)
GMSB	Годишник на музеите от Северна България (Варна)
GZM	Glasnik Zemaljskog muzeja Bosne i Hercegovine u Sarajevu (Sarajevo)
GZMS	Glasnik Hrvatskih Zemaljskih Muzeja u Sarajevu (Sarajevo)
HAH	Hereditas Archaeologica Hungariae (Budapest)

Hesperia	Hesperia. Journal of the American School of Classical Studies at Athens (Princeton)
História	História. A Magyar Történelmi Társulat, majd a História Alapítvány folyóirata (Budapest)
HOMÉ	A Herman Ottó Múzeum Évkönyve (Miskolc)
INMVarna	Известия на Народния музей – Варна (Varna)
IstMitt	Istanbuler Mitteilungen (Tübingen)
JAMÉ	A nyíregyházi Jósa András Múzeum Évkönyve (Nyíregyháza)
Jászkunság	Jászkunság. Az MTA Jász-Nagykun-Szolnok Megyei Tudományos Egyesület folyóirata (Szolnok)
JbAC	Jahrbuch für Antike und Christentum (Bonn)
JPMÉ	A Janus Pannonius Múzeum Évkönyve (Pécs)
KMMK	Komárom-Esztergom Megyei Múzeumok Közleményei (Tata)
LK	Levéltári Közlemények (Budapest)
MAA	Monumenta Avarorum Archaeologica (Budapest)
MacAA	Macedoniae Acta Archaeologica (Skopje)
MAG	Mitteilungen der Anthropologischen Gesellschaft (Wien)
MBV	Münchner Beiträge zur Vor- und Frühgeschichte (München)
MHKÁS	Magyarország honfoglalás és kora Árpád-kori sírleletei (Budapest)
MittArchInst	Mitteilungen des Archäologischen Instituts der Ungarischen Akademie der Wissenschaften (Budapest)
MFMÉ	A Móra Ferenc Múzeum Évkönyve (Szeged)
MFMÉ StudArch	A Móra Ferenc Múzeum Évkönyve – Studia Archaeologica (Szeged)
MMMK	A Magyar Mezőgazdasági Múzeum Közleményei (Budapest)
MŰÉ	Művészettörténeti Értesítő (Budapest)
MŰT	Művészettörténeti Tanulmányok. Művészettörténeti Dokumentációs Központ Évkönyve (Budapest)
NÉrt	Néprajzi Értesítő (Budapest)
NMMÉ	Nógrád Megyei Múzeumok Évkönyve (Salgótarján)
OA	Opvscvla Archaeologica (Zagreb)
Offa	Offa. Berichte und Mitteilungen des Museums Vorgeschichtliche Altertümer in Kiel (Neumünster)
PA	Památky Archeologické (Praha)
Prilozi	Prilozi Instituta za povijesne znanosti Sveučilišta u Zagrebu (Zagreb)
PrzA	Przegląd Archeologiczny (Wrocław)
PtujZb	Ptujski Zbornik (Ptuj)
PV	Přehled výzkumů (Brno)
PZ	Prähistorische Zeitschrift (Berlin)
RégFüz	Régészeti Füzetek (Budapest)
RGA	Reallexikon der Germanischen Altertumskunde (Berlin)
RT	Transylvanian Review / Revue de Transylvanie (Cluj)
RVM	Rad Vojvoðanskih muzeja (Novi Sad)
SbNMP	Sborník Národního Muzea v Praze (Praha)
Scripta Mercaturae	Scripta Mercaturae. Zeitschrift für Wirtschafts- und Sozialgeschichte Gutenberg)
SHP	Starohrvatska Prosvjeta (Zagreb)
SlA	Slovenská Archeológia (Bratislava)
SlAnt	Slavia Antiqua (Poznan)

SlSt	Slovanské štúdie (Bratislava)
SMK	Somogyi Múzeumok Közleményei (Kaposvár)
StComit	Studia Comitatensia. A Ferenczy Múzeum Évkönyve (Szentendre)
StH	Studia Historica Academiae Scientiarum Hungaricae (Budapest)
StSl	Studia Slavica Academiae Scientiarum Hungaricae (Budapest)
StudArch	Studia Archaeologica (Budapest)
Századok	Századok. A Magyar Történelmi Társulat folyóirata (Budapest)
TBM	Tanulmányok Budapest Múltjából (Budapest)
Tisicum	Tisicum. A Jász-Nagykun-Szolnok Megyei Múzeumok Évkönyve (Szolnok)
USML	Utrecht Studies in Medieval Literacy (Turnhout)
VAH	Varia Archeologica Hungarica (Budapest)
VAMZ	Vjesnik Arheološkog muzeja u Zagrebu (Zagreb)
VMMK	A Veszprém Megyei Múzeumok Közleményei (Veszprém)
WiA	Wiadomości Archeologiczne (Warszawa)
WMMÉ	A Wosinsky Mór Múzeum Évkönyve (Szekszárd)
ZalaiMúz	Zalai Múzeum (Zalaegerszeg)
Zborník FFUK, Musaica	Zborník Filozofickej Fakulty Univerzity Komenskóho. Musaica (Bratislava)
ZbSNM	Zborník Slovenského Národného Múzea. História (Bratislava)
ZfAM	Zeitschrift für Archäologie des Mittelalters (Köln)
ZHVSt	Zeitschrift des Historischen Vereins für Steiermark (Graz)
Ziegelei-Museum	Ziegelei-Museum. Bericht der Stiftung Ziegelei-Museum (Cham)
ZRNM	Zbornik Radova Narodnog Muzeja (Beograd)

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LÁSZLÓ BARTOSIEWICZ

FISH CONSUMPTION IN THE ARCHIEPISCOPAL RESIDENCE OF ESZTERGOM IN THE CONTEXT OF FISHING, AQUACULTURE AND CUISINE

Zusammenfassung: Der Fischverzehr spielte in der mittelalterlichen Ernährung eine besonders wichtige Rolle. Daher befassten wir uns im Rahmen der Auswertung jener Küchenabfälle, die aus der Residenz des Erzbischofs zu Esztergom stammten, verstärkt mit der gründlichen Analyse von Fischüberresten. Unser Ziel war es, die Artenzusammensetzung der in der Residenz verzehrten Fische zu bestimmen und ihre Körperlänge zu schätzen. Besondere Stärke der Forschungsarbeit ist, dass das komplette Material mithilfe der Schlämmanalyse aufgedeckt wurde. Dieser Methode ist es zu verdanken, dass wir nun zum ersten Mal in der Geschichte der ungarischen mittelalterlichen Archäologie ein differenziertes Bild über die Nutzung von Fischen erstellen konnten. Im Fundmaterial des 14. und 15. Jahrhunderts fällt die Zunahme des Anteils kleiner Karpfenfische auf, was auf einen Ursprung aus Teichwirtschaften hinweisen könnte. Auch das Vorkommen meist kleiner (junger) Hechte entspricht diesem Umstand. Der Anteil von Hausenüberresten im Fundmaterial ist auffälligerweise unbedeutend, obwohl mehrere Aufzeichnungen auf Hausenfang auf dem Gebiet des Erzbischofssitzes hinweisen. Ein Vergleich der sehr sorgfältig freigelegten Fischüberreste und der schriftlichen Quellen wird uns bei der differenzierten Auslegung dieser Phänomene behilflich sein.

Keywords: riverine fishing, fish farming, fish consumption, screening, cyprinids, pike, sturgeon, medieval period, Esztergom, archiepiscopal residence

One recurring commonplace in medieval sources is Hungary's richness in fish, regularly cited in the historical and ethnographic sources and the works that have determined fish studies.[1] The donation charters and lawsuits relating to fishing rights as well as the account books all underscore the economic significance of fishing. This is hardly surprising, given that the greater part of Hungary's territory, particularly the Little and the Great Hungarian Plain, was made up of the floodplains of the still unregulated rivers, extensive portions of which were intermittently or permanently covered with water. Moreover, the role of fish ponds and fish farming in food provisioning also increased.

Despite the natural and social environment conducive to fishing, medieval archaeozoological assemblages rarely contain fish remains. In an overview written in 1987, based largely on the available literature, hand-collected fish remains were known from no more than a dozen medieval sites.[2] Small fish bones can only be reliably recovered by screening. However, disregarding an experimental initiative over thirty years ago, which had little impact on archaeological fieldwork practices,[3] this procedure was not employed. The fish remains recovered through traditional hand collection restricted the fish species appearing in the archaeological record to the large acipenserids, pike, common carp and wels catfish, whose large bones are visible to the naked eye on excavations and are less concealed by the soil adhering to them. However, in order to accurately reconstruct fish consumption, an assessment of the smaller species such as the many small species

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1 E.g. *Bél 1764; Pfeiffer 1861; Pesty 1867; Herman 1885.*

2 *Takács – Bartosiewicz 1998* fig. 7.

3 Lászlófalva-Szentkirály: *Takács 1988;* Örménykút 54: *Bartosiewicz 1988.*

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in the cyprinid family and of the juvenile individuals of larger-bodied species is indispensable. The meticulous field procedures such as screening employed during the excavations at Esztergom provided an extremely detailed and statistically sound picture of the fish supply of archiepiscopal residence's kitchen and of the dietary customs of the castle's onetime occupants as well as of their waste management.

Species identification based on sampling provides meaningful data both on the incidence of particular species as well as on their absence, while providing only indirect, general data on the number of consumed fish and the volume of fish meat. In the case of medieval Esztergom, one intriguing issue is whether the fish remains recovered from particular layers originate from the Danube or a fish pond, particularly in view of the growing tendency of medieval carp consumption.

I am greatly indebted to Erika Gál, Eszter L. Kis Szabó, Róbert Lóki, Krisztina Orosz and Csilla Zatykó for providing data relevant to the interdisciplinary interpretation of the assemblage as well as for their own invaluable insights.

Material and method

Lying at the point where the Little Hungarian Plain and the Danube Bend meet, Esztergom was one of the most prominent political and cultural centres in medieval Hungary. Its castle overlooks the floodplain extending on the right bank of the Danube. The find material was recovered from the southern side of the castle, from the pits of one-time medieval stone quarries, in which the refuse discarded from the kitchen had accumulated to a thickness of several meters over the centuries.

Chronological distribution of the finds

The fish bones recovered in 2016 from the site registered as Esztergom-Kőbánya originate from the following find groups of the vertical layer sequence, corresponding roughly to the "chronological" order of the deposition:[4]

Group IV: The lowermost layer of the accumulated material, which aside from the kitchen's food refuse, contained also the occasional archaeological artefact. The relatively few finds were not sampled for radiocarbon dating and thus the 90 fish bones representing this group are discussed as part of the general overview in order to gain as complete a picture as possible. These finds were obviously part of the refuse of the overlying two groups and their complementary role is important for the overall assessment.

Group III: In the layer sequence, this is the middle, undisturbed section containing the bulk of the kitchen waste. The fish remains totalled 768. The single bone sample submitted for radiocarbon measurement gave a date of 1295–1395 cal AD (1σ; 1285–1400 cal AD, 2σ), i.e. the 14th century.

Group II: The late, upper, undisturbed section of the closed deposit containing kitchen waste. The amount of animal bones recovered from this section[5] is about one-half of the previous one (400 remains in the case of fish), also reflected in the number of bird and mammal remains. The single bone sample submitted for radiocarbon dating gave a date of 1405–1430 cal AD (1σ; 1330–1445 cal AD, 2σ), assigning the bone to the earlier 15th century. Both dates were made on the limb bones of domestic hen, a species that has a relatively short life span.

[4] The natural movement of the finds and their sedimentation at different scales must also be taken into account even if this refuse deposit was, to all appearances, undisturbed by contemporaneous human activity.

[5] Erika Gál's kind personal communication.

Given that the material of Group I collected from the top of the deposit was mixed, only the fish remains from Groups II and III could be reliably compared. The lowermost layer (V) on the floor of the quarry, containing also construction debris, differed visibly. Moreover, the two radiocarbon dates on bones for this layer are controversial (13th and 15th century, respectively); even assuming that the measurements are accurate, they are an indication of the unavoidably mixed nature of the finds.

Taphonomy
The extent to which an assemblage can be regarded as being representative is influenced by three interrelated taphonomic factors. The first, the material's state of preservation, is determined by the interaction between the material and the chemical environment of deposition, which also determines the extent to which species identification is possible. Finally, the recovery techniques and the care by which the finds are handled also contribute to the reliability of the broad picture outlined by the finds.

Preservation of the fish remains: Owing to the upward thrust of water, the structure of fish bones is not as compact as that of terrestrial vertebrates and a part of the loosely structured fish bones inevitably perishes in the ground. The skeletal elements of the economically important acipenserids (such as sturgeon and sterlet) of the order Ganoidei are particularly porous. In these species, the mineral content of the bones decreases with age. As a result of physiological osteoporosis, the large bones of older acipenserids survive to a lesser extent in archaeological layers. Additionally, since the finds come from kitchen waste, the taphonomic resistance of the loosely structured skeletal elements could be further worsened by cooking.

Taxonomic identification: The overwhelming majority (202 pieces) of the fish remains was highly fragmented, causing difficulties in taxonomic identification even to the family level. Although it could be determined even with the naked eye that these fragments predominantly came from small cyprinids and juvenile pike, the possible presence of other small fish that could not be identified owing to the fragmentation seems more than likely. The "indeterminate" category also includes those skeletal remains that have lost their articular surfaces and became undiagnostic such as rib fragments as well as the small flat bones of the skull. These remains can rarely be identified on the species level.

Recovery methods: It has been demonstrated that hand collection is unsuitable for the reliable recovery of fish remains because bones smaller than 17 mm – and most fish remains fall into this size category – will end up in the soil dump without sieving.[6] The excavation of the Augustine abbey at Sankt Pölten in Austria provided an opportunity to compare the efficiency of recovering the 15th-century fish remains if hand collecting and sieving are employed.[7] Roughly 85-90% of the small cyprinids were recovered from the sieved samples, and no more than 35-40% of the remains from large-bodied carp and pike were recovered by hand collection. Additionally, sieving doubled the number of large sturgeon finds too. The column on the left side of *fig. 1* shows the aggregate taxonomic breakdown of the fish remains from 23 medieval sites in Hungary compared to the fish remains from Esztergom. Given that until now, fish remains were exclusively hand collected at medieval sites and screening was not employed, samples are dominated by large-bodied sturgeon, catfish, carp and pike remains, while the remains of smaller-bodied species were rarely recovered and identified. At Esztergom, the soil from the culture deposit was dry sieved using 5- and 2-mm mesh screens.[8] Even a cursory glance reveals that one single sieved

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6 *Bartosiewicz 1988*.
7 *Galik et al. 2011* 102.
8 Eszter L. Kis Szabó and Róbert Lóki's kind personal communication.

sample of the archiepiscopal residence contained roughly the same number of identifiable fish remains as has been taxonomically identified altogether during previous medieval research.[9] Moreover, these two screened Esztergom samples offer a considerably more detailed picture, with large-bodied sturgeon and catfish representing a smaller proportion, while the frequencies of small-cyprinids and sterlet, the smallest species in the acipenserid family, increased. Thus, the Esztergom sample can only be compared to previously excavated medieval fish bone assemblages with some constraints because any differences are not taxonomic in nature, but can be ascribed to different recovery methods. The species composition of the Esztergom sample was both enriched and made more detailed by employing screening.

Estimation of fish sizes

The measurements of fish bones are suitable for calculating the one-time length of individual specimens. Even though few intact, measurable remains came to light at Esztergom, these finds are nevertheless important sources of information on fish consumption and can also be collated with the references in the written sources. By recording the bone dimensions according to the international protocol,[10] it proved possible to roughly estimate the size of a few specimens.[11] The acipenserid remains were compared to the last Hungarian great sturgeon caught at Paks in 1987.[12] The body length of pikes could be estimated by means of a recent comparative sample from Sweden,[13] while catfish sizes were calculated based on material in the Museum of Hungarian Agriculture.[14] In the case of cyprinids, the sizes published in the academic literature provided useful comparisons.[15]

Not being a historian, instead of the primary contemporaneous sources, I relied on the references in the secondary academic literature. One of my main sources was the information contained in the still unpublished kitchen account book *(pro Coquina castri)* of Hyppolite d'Este, Archbishop of Esztergom,[16] kindly provided by Krisztina Orosz. Written in 1489, during the reign of King Matthias, it provides a snapshot of the very end of period spanned by the archaeozoological material. Even if it does not reflect the entire period spanned by the fish remains from Esztergom, it does offer a reliable picture of its very end. Most of the detailed written sources on fishing in medieval Central Europe come from this period.[17]

In view of the different sample sizes, the significance of the even or differential distribution of the finds (homogeneity analysis) was controlled using chi-square (X^2) tests, applying the generally accepted 5% level of probability.

[9] This does not include the sites whose fish remains were simply denoted as "fish" within the entire animal bone samples, without a closer taxonomic identification.

[10] *Morales – Rosenlund 1979.*

[11] In the present study, these values refer to the total body length, measured from the nose to the tip of the caudal fins.

[12] *Bartosiewicz – Takács 1997* 13–14.

[13] *Bartosiewicz 1990.*

[14] *Takács 1987.*

[15] *Libois – Hallet-Libois 1988.*

[16] Hyppolite d'Este, cardinal of Ferrara, son of Ercole, prince of Ferrara, and Eleanor of Aragon, filled this post between 1486 and 1497.

[17] *Hoffmann 1997.*

Results

Table 1 presents the taxonomic composition and chronological distribution of the fish remains from Esztergom. Column 1, containing the few remains at the base of the deposit, is for information purposes only. The number of fish remains from the 14th century was twice as high as those from the 15th century. Owing to this difference, caution needs to be exercised when comparing the two groups since species representation depends directly on sample size.[18] Of the 1258 remains, 1056 could be identified to at least the family level. Although not fish remains, the few small claw fragments of crayfish reflect a nother freshwater dietary resource in the sample.

The species richness of the three groups differed. The 90 fish remains from the base of the deposit represented 8 taxa (species or family), while the largest, 14th-century sample exactly the double (16). The species richness of the 15th-century sample was even larger because 15 taxa could be identified in the half as large material. Of the fishes mentioned in the kitchen account book of Archbishop Hyppolite d'Este, carp, pike, barbel, Crucian carp and catfish were attested among the fish remains, but asp and burbot are also mentioned. Asp (*Aspius aspius* L., 1758) is a predatory cyprinid with a body length of up to 70-80 cm, while burbot (*Lota lota* L., 1758) is the single gadiform freshwater fish. It is sometimes called winter catfish because similarly to pike, it can be ice fished. Its body is 30-60 cm long. Despite their relatively large size, neither of the two species has been documented in archaeozoological assemblages from Hungary.

	Base of deposit	**14th**	**15th**	**Total**
		century		
Sturgeon (*Huso huso* Brandt, 1833)	1		1	2
Sterlet (*Acipenser ruthenus* L., 1758)	5	43	13	61
Large acipenserids (Acipenseridae)	2	35	15	52
Pike (*Esox lucius* L., 1758)	13	128	45	186
Common carp (*Cyprinus carpio* L., 1758)	21	120	95	236
Bream (*Abramis brama* L., 1758)		4	9	13
Barbel (*Barbus barbus* L., 1758)		4	2	6
Crucian carp (*Carassius carassius* L., 1758)	1	6	1	8
Ide (*Leuciscus idus* L., 1758)		8	2	10
Common roach (*Rutilus rutilus* L., 1758)	1	4	3	8
Tench (*Tinca tinca* L., 1758)		2		2
Vimba bream (*Vimba vimba* L., 1758)		3		3
Small cyprinids (Cyprinidae)	35	246	144	425
Wels catfish (*Silurus glanis* L., 1758)		17	4	21
Perch (*Perca fluviatilis* L., 1758)		2	1	3
Pikeperch (*Stizostedion lucioperca* L., 1758)	3	12	5	20
Indeterminate (Pisces)	8	134	60	202
Total	**90**	**768**	**400**	**1258**
Crayfish (*Astacus astacus* L., 1758)		**2**	**1**	**3**

Table 1. Species composition and chronological distribution of the Esztergom assemblage

[18] *Bartosiewicz – Gál 2007.*

The percentage distribution of the species in the 14th- and 15th-century sample is shown by the middle and right columns in *fig. 1.* On the testimony of the data, there was a statistically significant difference between the percentages of the 14th- and 15th-century fish remains relative to each other, despite the different sample sizes.[19] The percentage distribution of the larger fish groups in *fig. 1* are presented in *Table 2.*

	14th century (n=634)	**15th century** (n=340)
Sturgeon	0.0	0.3
Acipenserids	12.3	8.5
Pike	20.3	13.2
Cyprinids	43.8	**47.4**
Carp	19.0	**27.9**
Catfish	2.7	1.2
Percidae	1.9	1.5
Total	**100.0**	**100.0**

Table 2. Percentage distribution of the identifiable fish remains from Esztergom

The main reason for the differences between the two samples is that the proportion of cyprinids (including carp, which cannot always be accurately identified) rose from 62.8% accounting for two-thirds of the sample to 75.3% representing three-quarters of all remains during the 14th–15th centuries. The ratio of securely identifiable carp remains grew one-and-a-half-fold, which is particularly striking, while the frequencies of all other fish species obviously declined (the slight "increase" of sturgeon is not statistically significant i.e. could be accidental). In order to better understand this striking diachronic change, it seems instructive to survey the most important traits of the identified fish species and what we know about their exploitation.

Acipenserids

Of the identified fish species, the evidence for acipenserids will be reviewed first. The skeletal elements most likely to be preserved are the compact dermal scutes along the length of the body *(fig. 2d)* and the sturdy Y-shaped pectoral fin rays, which are to some extent suitable for species identification as well as for size estimations.[20] The two species that can be determined with relative confidence are sturgeon (with a body length of 2-3 m, although occasionally as long as 10 m), the largest in the family, and sterlet (1-1.2 m), the smallest. The extremes in bone sizes are illustrated in *fig. 2.*

Aside from sterlet and sturgeon, other members of this family found in the Danube include Russian sturgeon, ship sturgeon and stellate sturgeon.[21] The remains of the latter, not always securely identifiable owing to the transitional size of their bones, appear as large-bodied acipenserids in *Table 1.* The single measurable articulation point of a sturgeon fin ray was extremely large, indicating a body length of almost 3.5 m, came from the 15th-century sample. Although it could not be measured, the acipenserid fin ray fragment found at the base of the kitchen waste deposit *(fig. 2c)* was even sturdier. The early and late sturgeon finds provide the chronological frame for the otherwise scanty presence of large acipenserids in the kitchen waste of the archiepiscopal palace. The medieval value attached to the size of individual acipenserid

19 The sturgeon and catfish remains numbering less than five could not be included in this calculation.
20 *Brinkhuizen 1986* 18–33; *Desse-Berset 1994.*
21 *Pintér 1989* 26.

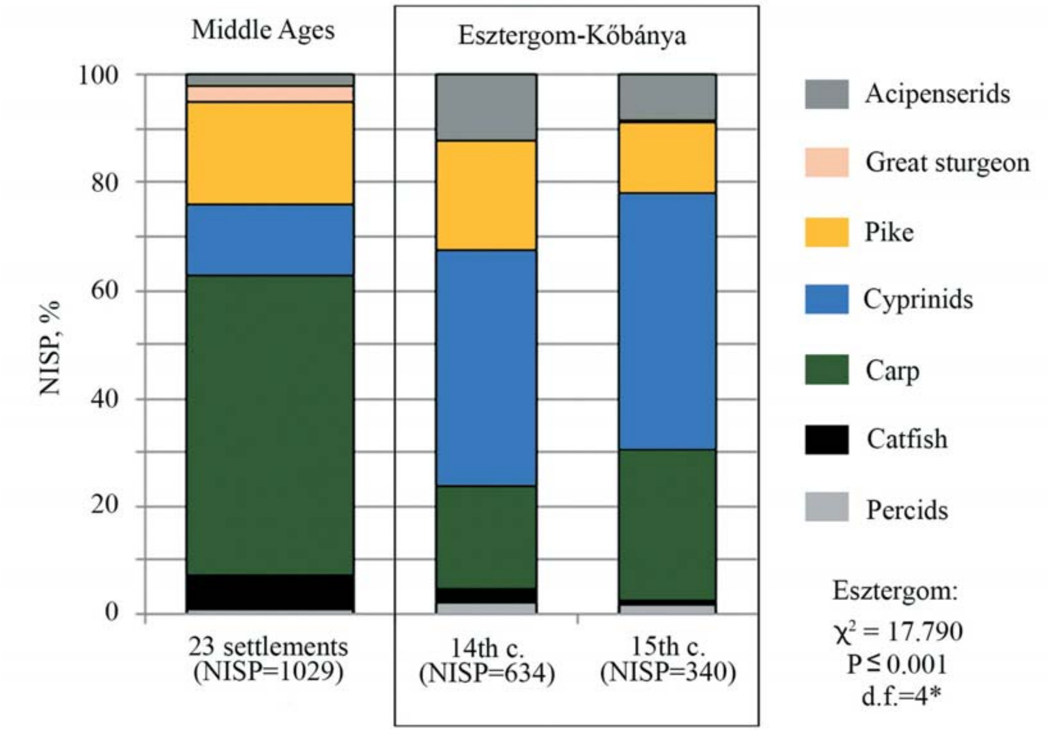

Fig. 1. The taxonomic composition of 14th- and 15th-century water-sieved samples from the Esztergom archbisopric in comparison with all medieval fish remains from Hungary. There is a statistically significant difference between the two framed samples from Esztergom (*Bones of acipenserids and catfish could not be included in the X^2 test due to the small number of cases)

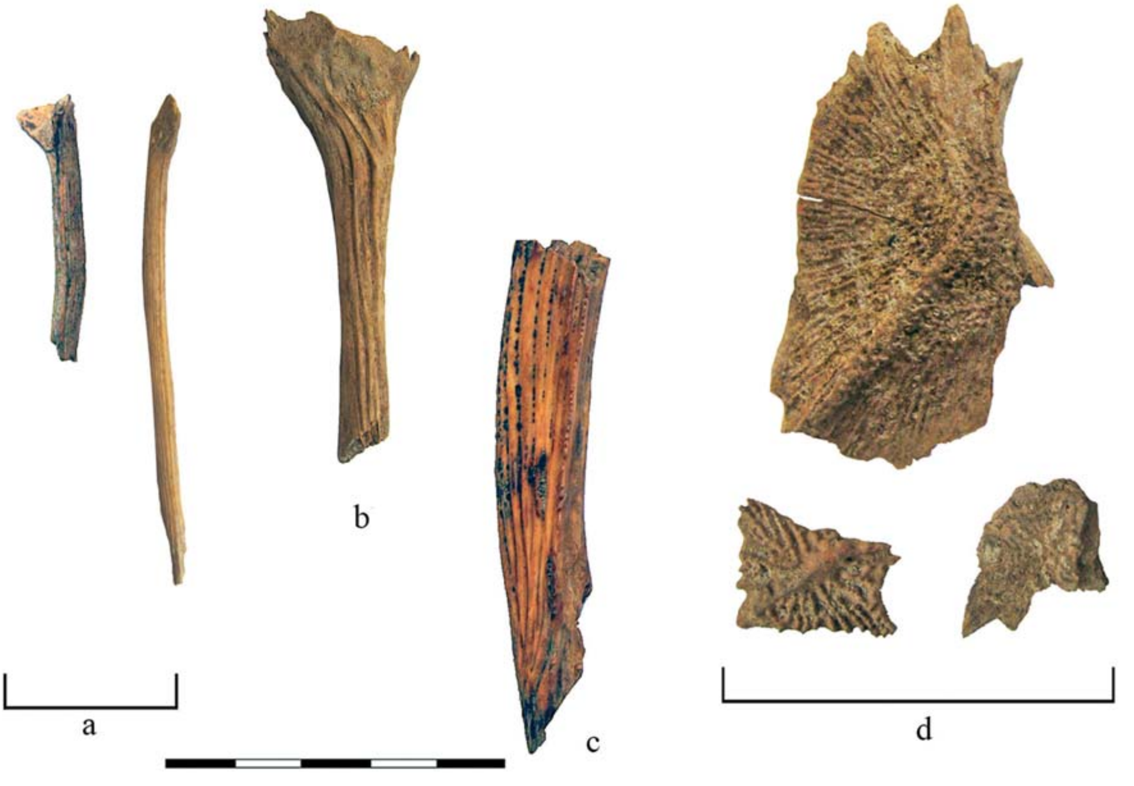

Fig. 2. Size differences between sterlet (a) and great sturgeon (b: 14th century, c: bottom layer) shown by pectoral fin rays and dermal scutes of large acipenserids (d) from Esztergom

species can be gleaned from the 1329 toll register of Zsolca, a town of the River Sajó: a toll of two *denarii* had to be paid for sturgeon, while only one *denarius* for the other species.[22]

Sterlet, the single specifically freshwater acipenserid, does not migrate far during the spawning season. Before the construction of the dams in the Iron Gorges of the Danube (1971 and 1984), individuals of the larger acipenserid species swam as far as the river's upper reaches from the Black Sea.[23] In Hungary, the migratory period falls between January and June, and October and December, respectively, depending on the species.[24] For fishers, the spring/early summer upstream migration was ideal. One established method was to channel the sturgeons into traps and weirs at river sections that could be easily blocked or target them at the mouths of tributaries. A good catch could be had at the deep sections of river beds, natural bottle-necks where the mass of migrating fishes piled up and became easy prey, as well as at the confluence of rivers, where sturgeons swam towards the narrower, faster-flowing tributary.[25] Writing at the turn of the 15th and 16th centuries, Ladislaus Suntheim recorded that of the great many sturgeons caught in Komárom, where the Vág/Váh river flows into the Danube, some were transported as far as Vienna.[26] About a generation later, in 1518, Komárom lying less than 50 km west of Esztergom, was elevated to the rank of Royal Sturgeon Fishing Grounds.[27] This is all the more interesting because the Esztergom archiepiscopate in the medieval county of Komárom "possessed 36-38 settlements, while in the 15th century, it owned only 20-22 settlements,[28] specifically in the part of the county extending north of the Danube", i.e. the river section between Komárom and Esztergom.[29]

According to the medieval account books[30] and early modern period cook-books,[31] caviar from female acipenserids migrating to spawn was a highly-valued delicacy. The fish returning to the sea after spawning no longer bore roe and now swam downstream, in part borne by the current, and thus were more difficult – and also less profitable – to catch.

Sterlet, the smallest species in the acipenserid family, is slightly larger than a fully-developed pike or carp. Compared to the latter two species, its demand for dissolved oxygen content is relatively high (3.0–3.5 mg/l),[32] and therefore prefers "more fresh" habitats. On the testimony of the fish remains from Esztergom, large, fully developed sterlets were regularly served in the archiepiscopal palace. Judging from the width of the first pectoral fin ray, the length of the 14 individuals was near 1 m, with the exception of a single 14th-century specimen *(Table 3).*

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[22] The latter corresponded to the toll duty for a horse, ox or a cattle driven to the market. *Tóth – Kubinyi 1996* 320–321.

[23] *Bartosiewicz et al. 2008* 39.

[24] *Bél 1764.*

[25] *Bartosiewicz et al. 2008* 47, fig. 10.

[26] *Pfeiffer 1861* 296.

[27] The occupants of Ács, a settlement located 10 km west of Komárom, caught sizeable sturgeons already in the Roman period: *Bartosiewicz 1989.*

[28] At the end of the 15th century, the archbishop of Esztergom ruled over 112 settlements in various counties: *Fügedi 1960.*

[29] *Csánki 1897.* This region, extending west of Esztergom, in part coincides with the Vágköz region, whose villages were famed for their fishing.

[30] *Kubinyi 2002* 249–261.

[31] *Herman 1884.*

[32] *Pénzes – Tölg 1977* 327.

Size range	Base of deposit	14th century	15th century
<100	93.9	75.0 84.5 88.3 89.7 93.9 94.0 95.6 95.7 96.6	
>100	100.9	100.0	100.9 103.4 107.8

Table 3. Body length estimates based on sterlet bones from Esztergom (cm)

The first pectoral fin ray rarely survives in its entirety and thus neither have any ratios been calculated for estimating body length. Of the ten intact pieces, one is very short (48.3 mm), one is fairly long (74.5 mm), while the average length of these bones is 58.7 mm (standard deviation=8.5 mm). This recalls the distribution of the values in *Table 3,* although larger individuals are slightly better represented among the intact fin rays.

Pike

Pike was a highly valued species, often served in the archiepiscopal residence. This fish is popular owing to its dry, white meat. It also has a symbolic value, as show, for example, by its appearance in coats-of-arms. One of the reasons for its popularity is that being a predator, it is active all year round; it does not burrow during the winter and was thus readily available with targeted ice fishing. Pike can be actively fished using hooks and harpoons, resulting in the catch of relatively large, solitary individuals.[33]

Fully developed males have a body length of *ca*. 1 m, while larger females can reach as much as 1.5 m. Sexual dimorphism of this magnitude evolves when the individual are around 8-9 years old. Although pike is a predator, it rarely attacks larger fish and its diet is mainly made up of small fish that are easy prey.[34] Its young feed on the larvae of cyprinids and later on any aquatic creature shorter than their own body, including their own young. One-summer-old pike is barely 20 cm long. The mouth of juveniles is disproportionately large and young pike sometimes prey on their smaller siblings.

When hunting, pike relies strongly on sight and is therefore regarded as an inhabitant of clear waters because good visibility conditions determine its habitat. However, if other fish are abundantly available, it will thrive in less clear waters, too.

At prehistoric sites, pike and small cyprinids tend to complement each other among the caught fishes. This species composition is typical for more-or-less euthrophic – slow flowing, even brackish – waters, whose soft bed is an excellent nutrient-rich soil for the aquatic plants on which its prey feeds.[35] The Bronze Age/Iron Age site of Wennungen (Sachsen-Anhalt, Germany) illustrates the leading role of these two groups of fish in the period's diet. Both smaller and larger

[33] *Kovács et al. 2010* 248.

[34] *Berinkey 1966.*

[35] *Heinrich 2013* 133.

individuals occurred among the pike remains at that site.[36] The bones of small-sized, young pike came to light at the Neolithic site of Ecsegfalva 23B. In view of their small, roughly 15-20 cm size, it seemed possible that they had become mixed up with small cyprinids, whose remains dominated the sample, during weir fishing (e.g. the use of basket traps in potting). The measurable pike bones in the Esztergom assemblage are the remains of 30-40 cm long or smaller fish, suggesting one-summer-old individuals. Only one skull fragment came from a fully-developed individual slightly longer than 80 cm *(Table 4).*

Size range	Base of deposit	14th century	15th century
<30	15.7	17.5 20.6 23.2	20.4 27.9
30–40		31.2 37.2 38.7	37.2
>40		83.3	

Table 4. Body length estimates based on pike bones from Esztergom (cm)

Even the relatively low number of remains reflects the chronological distribution of the bones: three of the seven pikes whose size could be estimated in the largest, 14th-century sample (i.e. in the most representative) were expressly small. This corresponds to the visual classification of the non-measurable pike remains. The very small-sized, young pike remains in the kitchen waste of the archiepiscopal residence in Esztergom account for 41.4% and 42.2% in the 14th and 15th centuries, i.e. there is no statistically significant difference in their presence during these two centuries ($X^2=0.020$, $P=0.924$, df =1). It seems likely that they reached the kitchen of the archiepiscopal residence together with the carp that had been caught en masse with nets.

It is instructive to compare the phenomenon noted in the screened bone assemblage with the 1489 kitchen account book of Hyppolite d'Este. Pike was considered to be a healthy food in medieval Europe – including the court of King Matthias – and its liver was regarded a royal delicacy,[37] Krisztina Orosz found that the archiepiscopal kitchen managed to acquire the fish fairly cheaply. While six carps were bought for 70 *denarii,* twelve pikes were purchased for 29 *denarii.*[38] In this case, carp was almost five times as expensive as pike (11.6:2.4=4.8). While two "large" carps are mentioned in another entry in the account book, there is no reference to the size of the pikes. The reason for their low price may well have been their small size. While it would not be prudent to draw far-reaching conclusions regarding the Danubian or fish pond origin, the collation of the osteological record and the documentary evidence nevertheless illustrates how the findings of different disciplines can be fruitfully integrated in the study of medieval life.

Cyprinids

Both assemblages from secure stratigraphic contexts from Esztergom are dominated by cyprinids, whose relative frequencies increased over time. Common carp, the largest species of this family in Hungary, can be often identified merely from the size of its remains:[39] the length of a fully developed carp, usually around 1 m, exceeds by far that of the other cyprinids (bream, Crucian carp,

[36] *Heinrich 2013* 129.
[37] *Csánki 1897.*
[38] Kisztina Orosz's kind personal communication.
[39] *Bartosiewicz et al. 1994a.*

tench, etc.) thriving in Hungary.[40] However, the species in this family can only be distinguished from one another based on diagnostic skeletal elements, principally the pharyngeal teeth needed for the processing of the large amounts of aquatic plants.[41] Aside from these, they can be securely identified from a few characteristic skull bones (such as parts of the mandible and the articular surface region of the gill cover), while the other non-diagnostic bones of young carp can only be identified on the family level and are inevitably assigned to the general group of small cyprinids.

Owing to its relatively large-sized bones, the continuous presence of wild carp[42] can be demonstrated in all Hungarian hand-collected assemblages. This species was an important source of food along the Hungarian sections of the Danube and Tisza rivers already in prehistoric times[43] and its continuous consumption is indicated by Roman-period remains from Austria.[44]

Native to the middle reaches of the Danube, carp spread beyond the Danube/Rhine watershed in the 11th–12th centuries, probably through the transport of live individuals to prominent secular and ecclesiastic centres.[45] Carp was part of the local wild fauna in France by the 1280s and in Poland by around 1530.[46] Yet, for example, assemblages rich in fish from the Cistercian monasteries of Łekno (1153–14th century) and Bierzwnik (13th–14th centuries) in central Poland contained no carp remains.[47] Farther north, in Sweden and in Finland, there are references to ecclesiastic and, later, to manorial and urban fish ponds from the 13th century onward.[48] However, these ponds were established for breeding Crucian carp and tench, and occasionally sterlet. Attempts were made in the mid-16th century to introduce common carp, but these were ultimately doomed to failure owing to the cold climate.[49] In our region, roughly two-thirds of the fish remains from Gaiselberg Castle in Lower Austria come from carp, most of which were recovered from post-1400 layers.[50]

The appearance and body proportions of the different carp species kept in isolated fish ponds changed, similarly as those of terrestrial species in the wake of domestication. However, it has proven impossible to convincingly identify the osteological traits of the domestic varieties. In Central Europe, a distinction was drawn by the early modern period between pond carp and Tisza carp *(Theißkarpfen),*[51] and the written sources also mention mirror carp with its modified scales of much fewer, but enormous "fish coins" and leather carp lacking scales *(fig. 3).* Although it is impossible to determine the role played by domestic carp gone feral and returning to natural waters from the fish ponds in the spread of these carp types, it was established by the 19th century that mirror carp was not a natural hybrid of wild carp and tench.[52]

Assuming that the length of the hyomandibular bone, on which the morphological differences between the different cyprinid species can be clearly identified, represents about 10% of the total body length of a fully developed carp, the estimated body sizes suggest the presence of not too large, but mostly full-grown specimens in the Esztergom assemblage (the full length of developed individuals is 40-80 cm). The length of the single smaller specimen is more or less identical with that of bream, also included in *Table 5.*

40 *Bartosiewicz et al. 1994b.*
41 *Berinkey 1966.*
42 *Balon 1995.*
43 *Bartosiewicz – Bonsall 2004; Bartosiewicz 2013b.*
44 *Galik et al. 2015* 346.
45 *Hoffmann 1996* 662.
46 *Hoffmann 1999* 191.
47 *Wyrwa – Makowiecki 2009* 65.
48 *Bonow – Svanberg 2016* 95.
49 *Granlund 1876.*
50 *Spitzenberger 1983* 139.
51 *Schmelzl 1547.*
52 *Beiträge 1833* 334.

Size range	14th century	15th century
<30		23.7* 25.2
30–40	36.7	30.7
>40	43.2 47.1 51.2	41.7 43.2

Table 5. Body length estimates based on carp bones from Esztergom (cm, *bream)

In this small series, the consumption of fish pond carp is indirectly suggested by the body lengths around 40 cm, which correspond to carp sizes at the time of harvest.[53] A similar size range is also attested among the non-measurable carp bones, which did not include the remains of exceptionally large specimens, while the smaller ones were assigned to the small cyprinids, which could not be identified more closely. Obviously, the few length estimates are unsuitable for statistically proving the source of these fish, although the law of large numbers would nevertheless suggest that the handful of measurable bones represent the size category of carp reared in fish ponds.

The other securely identifiable cyprinid species are the popular varieties still farmed today that have body lengths of 20-60 cm when fully grown. The individuals in the Esztergom assemblage represent the lower third of this size range. These species of the Esztergom assemblage are suitable for characterizing the freshwater environment and the fishing season. In the case of fishes caught in the Danube, the reason is that individuals venturing closer to the shore during the spawning season were more likely to be caught. Each species prefers a particular water temperature and dissolved oxygen content during spawning.[54] These two factors are closely interrelated with the flow velocity:

Fig. 3. Image of mirror carp from the book of *Marsigli 1726,*
written on the expedition he led along the Danube in the Ottoman Empire

[53] *Galik et al. 2015* 347.
[54] *Berinkey 1966.*

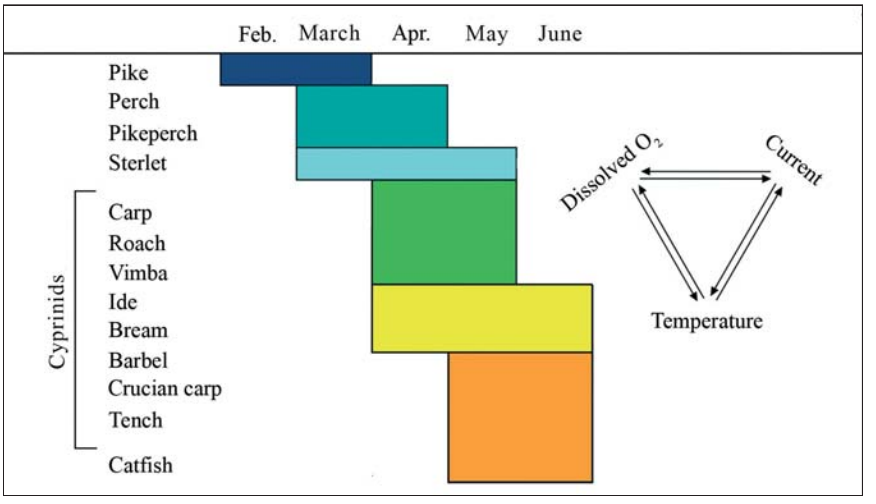

Fig. 4. Spawning seasons (months) of the species identified in the Esztergom find material. The interdependence between environmental factors determining spawning is shown to the right: dissolved oxygen, current and water temperature

swiftly-flowing, cooler water has a relatively higher dissolved oxygen content. Of the identified cyprinids, common carp and particularly tench have an expressly low oxygen demand (0.7 mg/l).[55]

An awareness of the spawning season of different species, the dominance of certain species in the archaeological assemblage provides indirect evidence for the most probable season of fishing *(fig. 4),* which offers important insights into the intermittently or seasonally occupied prehistoric settlements.[56] According to the spawning calendar shown here, the species identified in the kitchen waste accumulated in the abandoned pits of the quarry represent the entire spring season.[57] One interesting relevant piece of information in Hyppolite d'Este's kitchen account-book from 1489 is that the consumption of Crucian carp increased during April – no doubt in relation to the onset of the spawning season – as indicated by their purchase by the basketful.[58]

Percidae

Perch and pikeperch remains are scarce in the Esztergom material. As shown by the sequence of spawning seasons in *fig. 4,* both species prefer not too fast-flowing river sections with abundant water and still water rich in dissolved oxygen (2.0–3.0 mg/l),[59] avoiding stagnant habitats covered with loose sediment. Similarly to pike, their predatory nature requires good visibility, which is why they thrive in clear water. In the light of the above, it seems likely that the specimens in the Esztergom

Fig. 5. Fragmented mandibular element *(dentale)* of a fully grown pikeperch showing the typical "fanged" dentition

[55] *Pénzes – Tölg 1977* 327.

[56] *Pike-Tay et al. 2004; Bartosiewicz et al. 1994b.*

[57] Sturgeon does not appear here, because even though its spawning occurred in late spring/summer, its spawning grounds were not located along the Hungarian Danube section.

[58] Krisztina Orosz's kind personal communication.

[59] *Pénzes – Tölg 1977* 327.

assemblage originate from the Danube. Fully developed Percidae are generally 50–60 cm long, rarely attaining a length of 1 m. Pikeperch exceeding 1.5 kg are known as *fogassüllő* ("fanged" pikeperch) in Hungarian after their canine-like teeth *(fig. 5).* Perch is smaller, no more than 50 cm long at the most.

Wels catfish
Catfish is less sensitive to aquatic conditions, being a predator with few environmental demands.[60] Called "peasant-gobbler" in folk parlance, this large predator[61] can grow up to 2.5 m long and attain a live weight of 120 kg.[62] The 13th thoractic vertebra of catfish found in the 3rd-century Roman military fort of Izsa (Iža) in Slovakia, lying some 40 km west of Esztergom, had a horizontal diameter of no less than 42.2 mm, based on which the estimated total body length was over 2.5 m, meaning the individual weighed around 100 kg. This estimated weight would make it the fourth largest trophy catfish in Slovakia[63] However, similarly to pike, this species – often dominating hand-collected assemblages – is represented by small, young specimens in the Esztergom material. The total body lengths calculated from two intact cleithrums were 34.1 and 39.9 cm, respectively, and the non-measurable bone fragments also suggest similar-sized specimens. Catfish this size, strongly resembling carp of the same size, probably became mixed up accidentally with the netted cyprinids.

Anatomical composition of the finds and their distribution according to body regions
Compared to mammals, fish have a strongly differentiated skeleton with many elements. The skull is made up of the smaller neurocranium and the considerably larger viscerocranium or branchiocranium. These incorporate some 130 bones since the complex system of the protective covering for the gills are part of the viscerocranium. Pure meat can only be found in the region of the gill cover *(operculum)* in the case of most fish, but even in fully-developed carp, the meat is no more than a spoonful.

The zonoskeleton is the strong suspension system of the paired pectoral fins, linked to the bones of the skull, among which the paired cleithrum lies on the boundary of the head and the body. Cut-marks attesting to the separation of these two regions can occasionally be noted on these bones (regrettably, no such cuts were present on the fish remains from Esztergom). The pelvic girdle is represented by a single symmetrical bone *(basipterygium).*

The number of vertebrae varies even within species. The ribs attach to the ventral section of the vertebrae. The lower haemapophysis, typical for caudal vertebrae, is located on the ventral section, where no ribs are attached to the vertebrae towards the tail.

While the number of fin rays in live fish is an important taxonomic trait, their exact determination in archaeological assemblages is generally a hopeless task. However, irrespective of the great morphological similarities between fin rays, their presence is an indication that the fins of little culinary value had usually been removed during the preparation of fish dishes. The aggregation of the abundant identifiable skeletal elements in the Esztergom assemblage according to body regions provides a statistically testable sample. The chronological distribution is shown in *Table 6*.

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60 *Berinkey 1966;* Its late spawning period coincides, among others, with that of well-adapting tench.
61 *Gozmány 1979* 957.
62 *Pintér 1989* 135.
63 *Hensel 2004* 201; Neither is it mere chance that the neighbouring village 5 km to the west is still called Harcsás (Harčáš) ["catfish-full"].

Body region		14th century		15th century		Difference
		n	%	n	%	%
Head	neurocranium	31	4.5	11	3.0	-1.5
	viscerocranium	231	33.4	111	30.6	-2.8
Trunk	shoulder girdle	70	10.1	38	10.5	**+0.4**
	spine vertebrae	254	36.8	143	39.4	**+2.6**
	fin rays	88	12.7	54	14.9	**+2.2**
	scutes (acipenserids)	17	2.5	6	1.7	-0.8
Total		**691**	**100.0**	**363**	**100.0**	

Table 6. Breakdown of the fish remains from Esztergom according to body region

The body region distribution presented in *Table 6* reveals a slightly growing proportion of the bones of the trunk over time. However, this slight increase is insufficient for proving a statistically significant difference between the assemblages representing the two centuries, meaning that it could be accidental (X^2=3.848, df=5, P=0.572).

Of the most frequent species identified in the Esztergom material, the number of pike vertebrae total 61-64 per individual,[64] about two-thirds of which represented the meat-rich dorsal section, the rest belonged to the caudal region. Carp has fewer vertebrae, about 36-37 in all,[65] and the ratio of dorsal vertebrae is smaller, roughly equalling the number of caudal vertebrae in each individual. A comparison of the number of vertebrae from the two main sections of the vertebral column in the two most frequent fish species *(Table 7)* immediately reveals that the aggregate number of vertebrae from small-sized cyprinids corresponds to only the number in a single (!) individual, a major caveat regarding the quantitative assessment of the number of vertebrae, which cannot be statistically checked. In the 15th century, the meatier regions of pike seem to dominate among the finds from the archiepiscopal kitchen, while in the case of carp, this holds true for both centuries. The aggregate ratios shown in brackets in *Table 7* were strongly influenced by the dominant cyprinids.

	Dorsal	Caudal	Dorsal/Caudal ratio	Natural ratio
	vertebrae, n			
14th century				
Pike	17	9	1.9	≈2
Carp	8	3	2.7	≈1
Small-sized cyprinids	31	48	0.6	≈1
Total	**56**	**60**	**(0.9)**	
15th century				
Pike	11	2	5.5	≈2
Carp	12	9	1.3	≈1
Small-sized cyprinids	14	16	0.9	≈1
Total	**37**	**27**	**(1.3)**	

Table 7. Proportion of identifiable cyprinid and pike vertebrae from Esztergom

64 *Kiss 2000.*
65 *Kiss 2000.*

Fig. 6. Hacking mark inflicted by a cleaver/axe on the proximal articular end of a pectoral fin ray from great sturgeon found in the bottom layer

Acipenserids occupy a special position owing to their taxonomic status and anatomical structure. The so-called dressing percentage of fully-developed sturgeons, the proportion of meaty regions without the head and offal compared to the entire body weight, can be as much as 70% of the live weight.[66] Regrettably, the majority of surviving skeletal elements come from the head region; in the lack of vertebrae, not even an educated guess can be hazarded regarding the total weight of the meat on the trunk of a sturgeon.

There is a single exception to the not too easily identifiable fin rays of the other fish species discussed here: the first pectoral fin rays of acipenserids *(fig. 2a–c).* Their compactness ensures their preservation, enabling an archaeological assessment. While no cut-marks could be identified on the bones of other species in the Esztergom material, the proximal end of a fin ray chopped off with a cleaver was recovered from the base of the deposit *(fig. 6).* This confirms the taphonomic observation that heavy butchering tools and vehement blows were applied to the most resistant part of the animal body and therefore any cut- and chop-marks will most likely survive on such well-preserved, robust bones.[67] Less heavy cut-marks performed with a knife could be noted on a sturgeon mandible from the Roman fort excavated at Ács-Vaspuszta.[68]

This find from Esztergom appears to reflect the primary butchery preceding its processing in the kitchen and thus possibly comes from a fresh, not a salted sturgeon. Primary butchery was generally performed near the catch site by chopping the animals into chunks that could be packaged and transported,[69] leaving behind the entrails and other parts deemed unfit for consumption. It would appear that primary butchery was undertaken in the palace kitchen during the earlier period. The chop-mark reflecting primary butchery recalls King Sigismund's edict of 1405, according to which the Buda butchers could sell portions of large fish on their meat stalls and tables.[70] Similarly to livestock, the butchery of large specimens called for ample space, expertise and a set of sturdy implements.

Discussion

With the exception of large acipenserids, which by the late 20th century had disappeared from the Danube and had also adapted to salty seawater, the fishes consumed in the medieval archiepiscopal residence have all inhabited the Esztergom river section from prehistoric times to the present. At the same time, fish farming and fish ponds played an undeniably prominent role in medieval fish consumption, but since the same species were reared in them, it is zoologically virtually impossible to determine the closer origins of the fish remains.[71] The role of trade has

[66] *Bartosiewicz – Bonsall 2008* 72, fig. 2.
[67] *Bartosiewicz 2006* 79.
[68] *Bartosiewicz 1989* 621.
[69] *Bartosiewicz – Bonsall 2008* 42, fig. 8.
[70] *Kenyeres et al. 2008.*
[71] In medieval England, when fish farms suddenly provided freshwater fish to elite diets, their remains could be taxonomically easily distinguished from the bones of the traditionally consumed marine fish regarded as a mass commodity, *Grant 1988.*

been considered in the case of sturgeon because the scarce occurrence of large acipenserids can be taken as the most convincing evidence of active Danube fishing.

Riverine fishing

On the testimony of the currently known archaeozoological assemblages, the meat of large-bodied aciepenserids, principally of great sturgeons, which also figured prominently in the cuisine of the archiepiscopal palace of Esztergom, was most typical of elite sites in the medieval period.[72] The bones of large acipenserids have been identified among the finds from ten major secular and ecclesiastic medieval centres (including both the Árpádian period and the late medieval period). Among the ecclesiastic centres, sturgeon bones were identified in assemblages from the Dominican monastery in Buda Castle, the convent of the Poor Clares in Óbuda and the Cistercian abbeys of Zirc and Pilisszentkereszt. The finds from the archiepiscopal residence of Esztergom fit in nicely with these finds. One noteworthy phenomenon is that all the sturgeon finds from the known ecclesiastic centres date from the 14th–15th centuries; the sturgeon finds from secular settlements have a broader chronological distribution, although this could be a result of the differential intensity of the investigation of these sites *(fig. 7).*

The currently known medieval sturgeon finds occur most frequently at sites along the Danube section between Esztergom and Buda.[73] Only Zirc in Veszprém county, Sárszentlőrinc in county Tolna county, Szendrő Castle in the mountains of Borsod-Abaúj-Zemplén county and Romlott Castle in Zala county[74] lie far from this region. However, this does not merely reflect the exceptional abundance of fish in the Danube Bend, but also the concentration of investigated archaeological sites: the locations where record-size sturgeons were caught during the modern period have a considerably more even distribution along the middle section of the Danube crossing present-day Hungary.[75]

Sturgeon fishing in medieval Esztergom is amply documented in the sources. Sometime around 1411–1412, the bishop of Passau was entertained by János Kanizsai, Archbishop of Esztergom, and he visited a sturgeon catching location where the fishermen caught ten specimens within barely one and a half hours.[76] However, we do not know how far this place actually lay from Esztergom. According to studies on the economy of the Esztergom archiepiscopate, Gutha (Kolárovo), Nandor (Lándor) and Nazvad (Nesvady) in modern Slovakia were well-known locations of sturgeon fishing. These villages lay not near Esztergom itself, but some 60 km to its north, along the River Vág in present-day Slovakia.[77] The significance of the Danube section flowing through the Little Hungarian Plain through successive centuries is amply reflected by the dispute in 1206 between the settlements along the Vág regarding sturgeon fishing and the use of fish ponds.[78] According to the documents of the butchers' guild of Buda, sturgeon and other acipenserids were transported to the capital by the fishermen of Esztergom, Nagymaros, Megyer and Óbuda from the west and from Szentlászló lying on the river's opposite bank.[79]

The basic hydrological traits of the Danube in the broader area of Esztergom, a town founded at where the plain and the mountains meet, have changed relatively little since the maps of the First Military Ordnance Survey were made (1764–1784) *(fig. 8)*. Given the topographic conditions, the

[72] One indication of the prerogative to sturgeon fishing is that in 1432, the two sturgeons caught on the Palkonya estate of the Eger chapter was forcefully confiscated from the serfs: *Tóth – Kubinyi 1996* 279.

[73] *Bartosiewicz – Bonsall 2008* 38–39.

[74] *Tugya 2017* 188.

[75] *Khin 1957.*

[76] *Zolnay 1977* 96–121.

[77] *Nyáry 1870* 362.

[78] *Novák 2005* 48.

[79] *Kenyeres et al.* 2008.

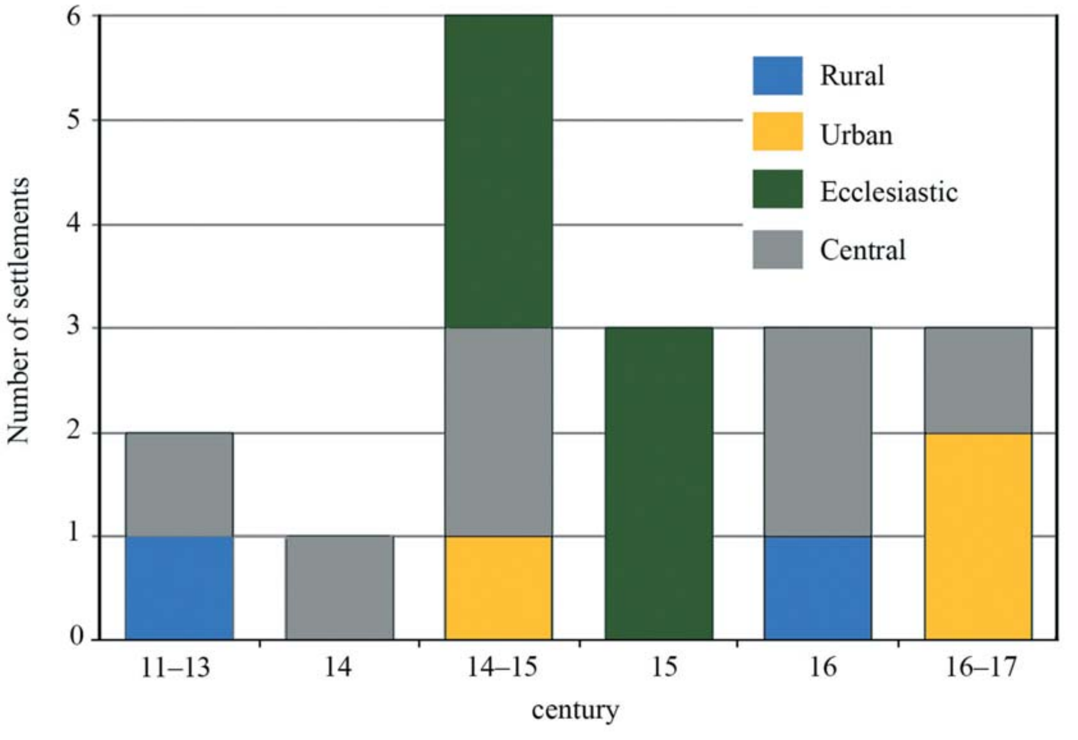

Fig. 7. The diachronic distribution of great sturgeon remains by settlement type found at medieval sites in present-day Hungary

single area suitable for sturgeon fishing near Esztergom Castle was the relatively wide and slower-flowing river section incorporating Prímás Sziget to its south. The velocity of current increases gradually in the narrowing river bed toward the north among the mountains where the river turns into the Danube Bend gorge, decreasing the chances of a good catch. One of the illustrations to the Italian military engineer Luigi Fernando Marsigli's book published in Amsterdam in 1726 shows how sturgeons swimming upstream were caught by constructing weirs on the sandbars at the "base" of the Iron Gates gorge towards the Lower Danube. However, hydrologically that environment has more in common with Leányfalu than with Esztergom, the latter being located upstream in relation to the Danube Bend gorge.[80]

Aside from large-bodied sturgeon, the overwhelming majority of the fish species from Esztergom are eurytopic species, meaning that they can thrive in various freshwater environments, amidst relatively broad water quality boundaries. There are only a few interesting exceptions: in addition to percidae, barbel and vimba bream are rheophilic species, preferring faster-flowing water. These two small-sized cyprinids have more recently also be found in two streams of the Visegrád Mountains.[81] The crayfish remains in the Esztergom material also indicate the exploitation of habitats with smaller watercourses since this species is extremely sensitive to water quality.

[80] *Bartosiewicz – Bonsall 2004* 267, fig. 8. On Marsigli's drawing, the direction of the Danube's outward flow is indicated with an arrow.

[81] *Weiperth et al. 2015* 52.

Fig. 8. The Danube near Esztergom in the map of the First Military Ordnance Survey (1764–1784). Note the northward turn of the river as it enters the Danube Bend gorge downstream. The arrow marked É indicates north

Fish farming

The advantage of fish ponds was that they provided a more-or-less even supply and functioned as “living meat reserves”[82] to complement riverine fishing. Undoubtedly, the fish species listed in *Table 1* were all available from the Danube. However, despite the undeniably favourable location of Esztergom in terms of fishing, the success of the catch was strongly influenced by the unpredictable changes in the water regime, which depended on the season and weather.[83]

The most striking insight provided by the bone material of the archiepiscopal residence is the statistically significant increase of cyprinids during the 14th–15th centuries. There is no indication of a radical climate change: although the period in question came after the medieval climate optimum, there was no extreme cooling in Hungary during these two centuries; the annual mean temperature was roughly the same. This raises the issue of what was the reason for this immense change in consumption, given the river’s more or less stable fish fauna.

The medieval upswing in fish farming led to a series of innovations across Europe. There is evidence for the intentional modification of fish habitats such as the construction of fish ponds by damming streams from the 11th century onward.[84] In France, various local procedures for keeping and breeding carp, pike and other fish for fast-days are documented as early as the 12th century. Fish ponds could be found across the major part of Europe by the 13th century.[85]

In natural waters, the best season for fishing was spring and summer, and thus the demand for fish for the forty days of fasting before Easter and the June fast associated with the Feast of

[82] This shrewd remark, originally referring to early domestic mammals *(Bökönyi 1989),* is valid for the fish raised in the fish farms too.

[83] *Figler et al. 1997.*

[84] *Hoffmann 2000.*

[85] *Hoffmann 2002.*

St. Peter and St. Paul could be easily met. In contrast, catering to the unceasing demand for the winter fast days from natural waters must have run into considerable difficulties.[86]

Fish farming emerged gradually from the fish ponds designed to store fish caught in the wild for fast days. Even though written records for the creation of ecclesiastic fish ponds are by far the most informative, the ponds themselves probably played many different roles in medieval food production, depending on the different geographic properties (topography, extent of forestation, proportion of water-covered areas and their seasonal changes) and their social role (rural and monastic fish farming, royal fisheries). A systematic coverage of the information on riverine fishing and aquafarming in the written sources will no doubt contribute to illuminating several issues in connection with fish consumption in Esztergom.

The practice of constructing fish ponds arrived to Hungary from the west. The Cistercian monastery founded in Waldsassen in 1133 *(Sacer Ordo Cisterciensis)* in the German-Czech border region established the Egerland fish pond around 1220.[87] The first installation of this type in Bohemia dates from 1263, and we know of a further 87 ponds during the period between 1347 and 1418, corresponding roughly to the period spanned by the fish remains from the archiepiscopal residence of Esztergom. Water management between 1450 and 1550 led to the transformation of the Czech landscape: large rivers were diverted and extensive ponds were created.[88] These fish ponds eventually played a role in supplying the Vienna fish market, too.[89] Although this process began roughly a generation later in southern Poland,[90] a manual on the creation and management of fish ponds written by Janus Dubravius, bishop of Olomouc, dedicated to the Fugger and Thurzó families was published in Wrocław.[91]

There were an estimated three to four thousands fish farms during the 11th–13th century in Hungary.[92] The archaeological remains of medieval weirs and dams indicate that fish ponds were established in the Búbánat Valley lying at the entrance to the Danube Bend gorge after the 13th century.[93] The springs flowing across the waterlogged valley floor could be easily dammed to create ponds. The management of these fish ponds can in all likelihood be linked to the Ákospalota residence established in the Árpádian period, which was rebuilt in the 16th century and enlarged with a game park (*MRT 5* site no. 8/115–116), and came into the possession of the archiepiscopate in the late 14th century.[94]

Medieval fish ponds were probably harvested opportunistically, according to the momentary demand for fish; however, with the technological advances in aquafarming, fish began to be separated according to age cohorts: spawning ponds for the females, ponds for rearing the fry, and fattening ponds for the market. Aside from carp, ponds were also stocked with other species in order to eliminate the competitors for carp, the less valuable smaller fish. Thus, by the 14th century, pike became an important by-product in developed aquafarming. Moreover, the high number of fry produced by carp with which the ponds were annually restocked would have led to overpopulation; the stock of carp fry was reduced by also stocking relatively young pike, in

[86] *Wyrwa – Makowiecki 2009* 67.

[87] *Muggenthaler 1924* 129–131.

[88] *Andreska 1984.*

[89] *Wacha 1956.*

[90] *Szczygielski 1967.*

[91] *Dubravius 1547.*

[92] *Pesty 1867* 68. Although this estimate might seem an exaggeration at first sight, we know that there were as many as 25,000 fish farms in Bohemia by the late medieval period in the wake of the upswing in fish farming: *Hoffmann 1999* 191.

[93] Csilla Zatykó's kind personal communication.

[94] *MRT 5* 219–221.

a sense a mirror of the natural balance of the fish fauna in natural waters.[95]

Less frequently, ponds were stocked with pikeperch and catfish whose meat was highly valued. In 1495, when the Bishop of Eger entertained the king, six thousand carp, sterlet, burbot, catfish and trout were served. Only pike, the abundantly represented species in archaeozoological assemblages is missing from this list, while sterlet and catfish are present.[96] The small individuals of the latter species in the Esztergom material are noteworthy in relation to aquafarming because fully developed, voracious catfish would have wreaked havoc in the valuable carp stock of an artificial pond.

Fig. 9. Pathologically fused caudal vertebrae of a small cyprinid from the 14th century assemblage

The screened material from Esztergom also offers other interesting cases. The two fused caudal vertebrae of a small cyprinid *(fig. 9)* is an unusual find. While the most obvious explanation for a fusion of this type is the old age of the fish, this cannot be conclusively established in this case: it remains uncertain whether these bones come from a very old bream or a young carp with a developmental disorder. Aside from old age and inherited traits, this anomaly can be a sign of phosphorus deficiency or the consequence of a parasitic infection (such as whirling disease, *Myxobolus cerebralis,* in the case of farmed salmonids).[97] Remains with pathological alterations are statistically more likely to crop up among screened finds. A similar fusion of vertebrae has so far been noted among Atlantic cod remains, identified by the thousands, although in no more than three cases.[98] One may reasonably ask whether these vertebrae, spectacularly recovered through careful screening, a technique rarely employed in Hungary, possibly represent a "domestic" fish influenced by aquafarming among the 711 identified cyprinids bones. Although there is nothing to support this assumption, the tendency is noteworthy, given the law of large numbers.

The culinary aspects of the fish remains from the archiepiscopal residence

One standard practice in Hungarian archaeozoological studies is the assessment of the animal remains directly indicating meat consumption in the context of their reconstructable social setting.[99] Rural villages and larger settlements reflecting urbanisation can be relatively easily identified. The high-status royal, ecclesiastic and military administrative centres assigned to the third settlement type represent a much more heterogeneous group, which has received greater attention in historical and archaeological studies. Here, I shall statistically compare the archaeozoological findings with a single written source only.

[95] *Bourquelot 1863* 71.
[96] *Bartosiewicz 2008* 105.
[97] *Kivikero 2018* 285.
[98] *Harland – Van Neer 2018* 266; *Kivikero 2018* 282.
[99] *Bartosiewicz 1999.*

Anna Bornemisza's cook-book[100] is the best-known collection of recipes written in Hungarian from the Early Modern Age, a somewhat revised version of the original work written for the prince-elector of Mainz in 1581[101] and translated into Hungarian from German by János Keszei. The recipes in this cook-book are a reliable reflection of how food was seen to be an important element of social display as well as of the tastes of the Central European sovereigns.[102] The 39 fish species appearing in the book account for about one-third of all animals. The abundant variety, in which marine fish species were also included, although contradicting somewhat the strict fasts imposed by the Church, was no doubt meant to enliven the austere diet of the long fast periods as would befit a royal table.[103] It should be noted here that similarly to Transylvania and Esztergom, the royal court in Mainz lay at quite some distance (450 km) from the sea.[104]

In part owing to the recipes calling for marine fish, no more than one-half of the fish species mentioned in Anna Bornemisza's cook-book were identified in the Esztergom assemblage. It is nevertheless striking that the proportion of recipes for freshwater fish relative to each other more-or-less corresponds to the percentage frequencies of the fish remains from Esztergom *(fig. 10).* Regrettably, the erratic data of the species less represented in the cook-book and the find assemblage (but over-represented in the recipes compared to the find material) detract from the statistical significance of total similarity. If the estimates are restricted to the dominant portion of "common" farmed fishes (sterlet, carp and small cyprinids: 93 recipes and 773 remains), there is no statistically significant difference between the taxonomic composition of the written source and the kitchen waste. Disregarding sturgeon, a luxury delicacy, the dishes prepared in the kitchen of the archiepiscopal residence reflect the consumption of fish species corresponding to the ratios outlined by the cook-book's recipes that could be acquired from fish ponds and were regarded as quotidian in Central Europe. Carp and pike were consumed in abundance, as reflected also in the account books. In April 1489, when King Matthias and the Bavarian prince visited Esztergom, the archiepiscopal court purchased 400 carp and pike each,[105] even though the archiepiscopate had its own fish ponds, an indication both of the outstanding fish consumption on an auspicious occasion and a confirmation of the regular role of carp and pike in the daily diet, reflected in the bone material.

Neither should the diachronic increase of small cyprinids in the diet of the archiepiscopal residence be belittled. Aside from cyprinids, the remains of other small-bodied fish (European bullhead, weatherfish, river lamprey) have not yet been identified at Hungarian archaeological sites.[106] However, the sieved assemblages from several sites in Germany and Switzerland clearly demonstrate that the population of medieval Europe had a definite taste for these small-bodied species and for similar-sized young farmed fish, which were both consumed in great quantities,[107] for they also appear among the period's recipes.[108] In terms of food preparation techniques, the small-sized pikes represent exactly the same size range.

The body part composition of the Esztergom assemblage also has some insights to offer. *Tables 3–4* reveal that the material from both centuries contained a relatively high number of skull remains, even allowing for the fact that one individual can have over a hundred cranial

[100] *Lakó 1983.*
[101] *Rumpolt 1581.*
[102] Recipes for virtually all imaginable creatures were included: *Herman 1884.*
[103] *Jaritz 1987.*
[104] The meat of freshwater fish from the fish ponds represented a higher level of luxury in the medieval cuisine of England, a land abounding in marine fish: *Woolgar 1999* 120.
[105] *Nyáry 1872.*
[106] *Galik et al. 2015.*
[107] E.g., *Heinrich 1995; Brombacher et al. 1998; Nussbaumer – Rehazek 2007.*
[108] *Bartosiewicz 2013a.*

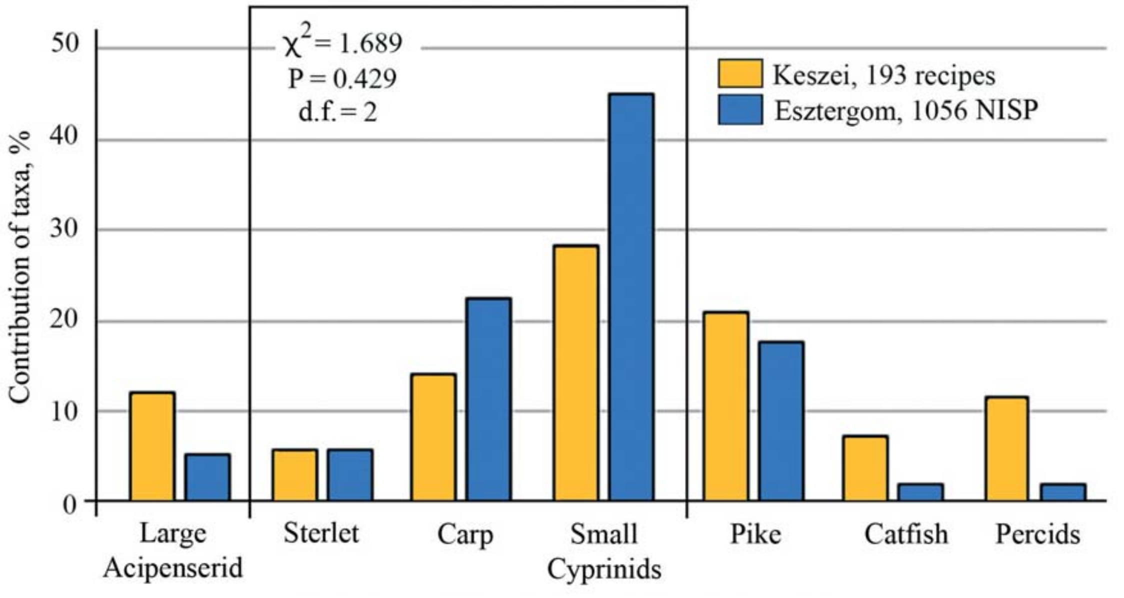

Fig. 10. Similarities between the relative frequencies of fish species mentioned in the 17th-century cookbook of Anna Bornemisza and the 14th–15th-century fish remains from Esztergom. Luxury fish are represented by more recipes than ordinary species. No statistically difference was found between the representation of ordinary species (framed)

bones. Fish heads, poor in meat, are still important, popular ingredients for fish soup and fish sauces, explaining in part the impressive proportion of skull bones in the kitchen waste. At the same time, we have no way of knowing how many fish heads had actually been served and how they had been prepared, e.g. as whole grilled fish. We can also reckon with discarded raw fish heads, whose scattered bones can no longer be distinguished from the remains of prepared dishes.

The skull bones account for about one-third of the assemblage, while the trunk bones, including rib fragments, did not total even one-half of the remains. This raises the question of whether remains of the food served had perhaps been discarded elsewhere, for example into cesspits, explaining their lower number in the kitchen waste accumulating in the pits of the quarry. The porous vertebrae of "royal" sturgeon, occupying a prominent role in the cook-books written for the elite, have not been found in Hungarian archaeozoological assemblages. The consumption of sturgeon rich in meat is at best indicated by finds of the sturdy, ornate ganoid scutes on the head and running along the back and two sides of these species *(fig. 11, E-F).*

The environmental impact of the kitchen of the archiepiscopal residence

Yet another aspect must be briefly covered regarding the activity of the archiepiscopal kitchen as reflected in the screened archaeozoological material. The organic refuse dumped continuously into the pits of the former quarry, including decaying fish remains, was no doubt the source of foul smells and, in certain months of the year, the hotbed of flies and various other bugs and their larvae. The recovery of insect remains calls for the use of sieves with a finer mesh; however, the contribution of tiny rodent bones identified in the sieved material is consistently over 1% in both centuries (14th century: 1.5%; 15th century: 1.26%). These probably represent murids, mice and rats.[109] Their constant presence corresponds to what we know about kitchen waste deposits. The small fragment of a cat's temporal bone among the 14th-century fish remains can be regarded more as a cranial element representing a commensal creature than typical food refuse.

[109] Cf. Erika Gál's study in this volume.

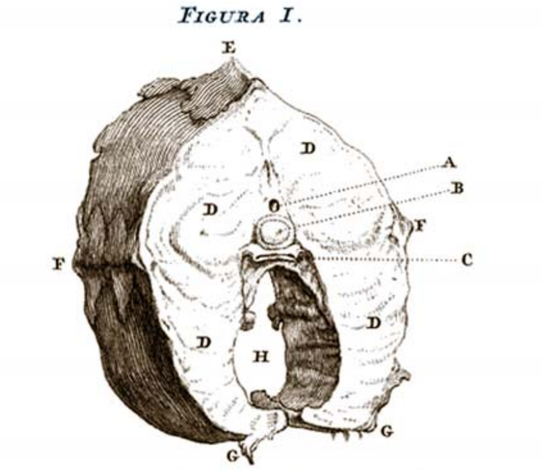

Fig. 11. Meat rich parts shown in the cross section of a great sturgeon after *Marsigli 1726*. The dorsal (E) and lateral (F) dermal scutes are marked

It cannot be mere chance that the enormous amount of refuse was dumped on the castle's southern side, below the level of medieval occupation. The prevailing winds on the Little Hungarian Plain conform to the prevailing north-western wind direction in Hungary, which follow the movement of the body of air flowing through the Dévény/Devín, Slovakia wind gate. Accordingly, the gusts of north-westerly winds swept the foul smells of the kitchen waste from the archiepiscopal palace towards the town and not towards the castle *(fig. 8)*. This spatial organisation corresponds to the location of several medieval tanneries (the Tabán in Buda, Pest, Vác), where the beneficial Danubian winds swept away the greater part of the air pollution from the elite residential quarters.[110]

Conclusion

Fish consumption at the archiepiscopal residence of Esztergom was modest in terms of its quality. The assemblage contains but a few sturgeon bones, a hallmark of luxury, while much-appreciated pike is mostly represented by small-sized specimens. The perhaps most important observation is the significant increase in the consumption of carp and small cyprinids, both "mass products", during the late medieval period examined here, which principally raises thequestion of how these fish were procured.

Palaeoecological and archaeozoological studies have demonstrated dynamic changes along the Austrian and Hungarian sections of the Danube during the medieval period.[111] However, it would be succumbing to environmental determinism not to be aware of the fact that a part of these changes was a consequence of human activity. The analysis of fish remains from the Esztergom residence and documentary sources both indicate that in addition to traditional riverine fishing exploiting the hydrological potentials of the Danubian floodplain, fish procured from fish ponds too may have played a significant role in the consumption of the archiepiscopal kitchen.

During an earlier study of prehistoric fishing in the Danube, it was possible to map the interaction between the main elements of fishing by applying factor analysis to ethnographic data on traditional artisanal fishing recorded in 32 locations around the world.[112] Those results provide an appropriate context for a summary overview of the issues raised in connection with the fish supply at Esztergom *(fig. 12)*. The two axes perpendicular to each other represent two independent concepts. The data points illustrate the proximity of the considered factors in terms of the concepts of "traditional" and "commercial" fishing.[113]

In the case of Esztergom, the variables associated with a positive sign with traditional fishing (x axis) are related to the Danube. The continuous reproduction of the fish stock is crucial in natural

[110] *Bartosiewicz – Bózsa 2009.* Similar principles of orientation can be noted in the case of the rather odoriferous processing of purple dye, i.e. Murex shell in the Mediterranean: *Bartosiewicz 2003.*

[111] *Haidvogl et al. 2015.*

[112] *Bartosiewicz – Bonsall 2004* 270, Table 8.

[113] The percentage values along the two axes indicate that these two concepts roughly account for 20% each regarding the variance represented by the studied phenomenon.

waters, which called for the protection of the stock and the fry. The over-fishing of the natural waters by the late medieval period indicates that this sustainability ethos known from ethnographic examples no longer sufficed. In the case of the Danube, a series of laws promulgated in 1412 forbidding the use of fine-meshed nets in order to spare the young ensuring the replenishment of the stock of valuable large-bodied species on the river's Austrian section are another indication.[114] Overpopulation, a variable with the smallest value in the negative range of the horizontal axis, was hardly a practical problem posed to traditional fishing in the case of rivers.

The best example for commercial river fishing represented by the vertical axis in the case of Esztergom is sturgeon fishing. The construction of weirs and sturgeon fishing in general was an endeavour calling for investment and co-ordinated group labour. In the 16th century, the serfs of several villages were sometimes mobilised to construct weirs from oak logs under the direction of the *magister clausurae*.[115] The closure of the Danube across its entire breadth, even with light structures, which on the testimony of a document dated to 1528 led to litigation between the fishermen of Vác and Buda, must have called for an enormous labour investment.[116] The mass processing of the caught fish (as well as the procurement of salt, if necessary) and their transportation to the markets conforms to the criteria of industrial-like logistics.

Even though sturgeon remains were identified in the kitchen waste, the commercial fishing of sturgeon – unlike in the case of other fishes – is indicated by lack of any references to the purchase of sturgeon in the kitchen account book of 1489,[117] or in any other known source relating to Esztergom. A remark by an Italian scribe (*usoni venduti*, "sold sturgeon") would suggest that the sturgeon finds from the archiepiscopal residence originated from the archbishop's own estates, which according to the account books sold salted surgeon in Guta and Naszvad in the late 15th century.[118]

While in the case of Esztergom there is no evidence for species quotas resembling the practice in marine fishing, there were regulations restricting sturgeon fishing, of which the best examples are the royal and noble prerogatives as well as the spatial limitations as expressed by land tenure conditions. Their role in traditional fishing was much less significant, but nevertheless became dominant by the late medieval period in Hungary.

Technology is more closely associated with commercial-type fisheries than with traditional fishing. Similarly to the construction of weirs, the establishment and maintenance costs of fish ponds, which in turn impacted the market price of fish, also fall into this category.[119] This was the case even if the costs could not always be expressed financially (*corvée* labour, payments in kind, etc.): power and money were the prerequisites to establish fish ponds.

The position of the data point for fish overpopulation indicates that this risk was real in aquafarming, which approximated industrial production. Suffice it here to recall the custom of stocking ponds with pike,[120] which in Esztergom can probably be associated with the strikingly high proportion of small-bodied specimens, often the length of one-summer-old pike, probably caught together with cyprinids.

Compiled on the basis of ethnographic examples, *fig. 12* shows that the imposition of temporal restrictions has been important both in traditional and commercial fishing. A 12th-century

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[114] *Uhlirz 1900.*

[115] *Bencsik 1970* 73.

[116] *Bartosiewicz 2008.*

[117] Krisztina Orosz's kind personal communication.

[118] *Nyáry 1870* 368; The illustration to Marsigli's book, published in 1726, depicts how the fishermen of the Iron Gates weigh and dismember sturgeon before packaging them in large barrels, probably preserving them with salt, as was customary: *Bartosiewicz – Bonsall 2008* 42, fig. 8.

[119] *Woolgar 1999* 120.

[120] *Bourquelot 1863* 71.

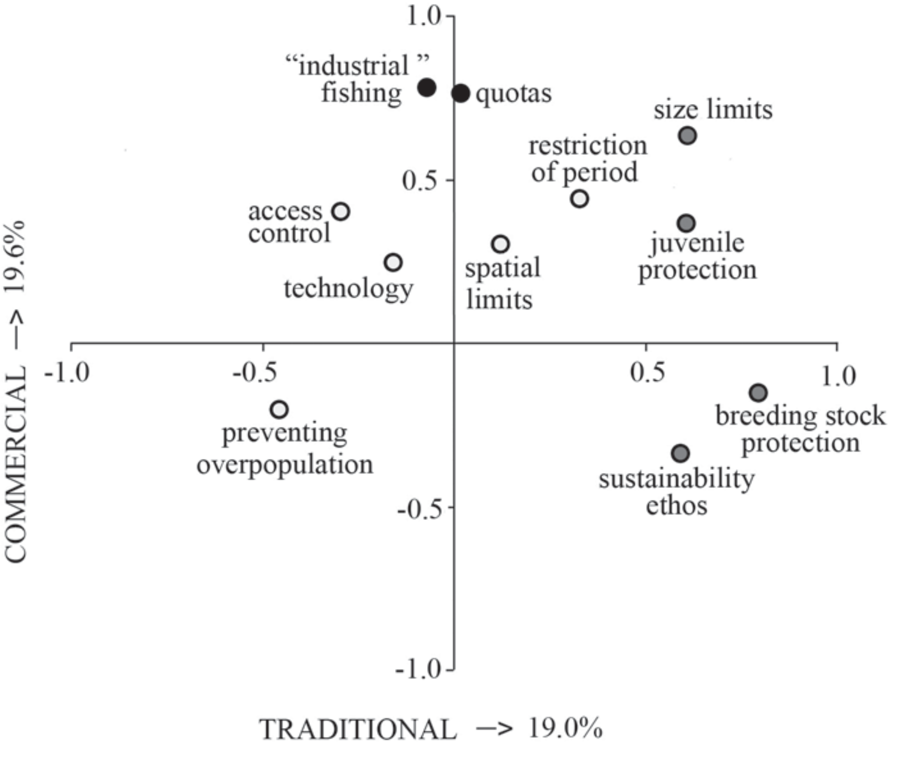

Fig. 12. Relationships between the determining factors in traditional and commercial fishing based on 32 ethnographically documented fisheries world-wide

English decree restricted fishing with nets from boats to Thursdays in Warwickshire, probably with a view to the Friday fast.[121] As indicated by modern fishing regulations, the spawning rush is the most sensitive time in the life of fish stocks on the seasonal scale, even if the easiest catch coincides with this period. This is best illustrated by the regular predation on sturgeon migrating to their spawning grounds, in part to meet the demand for caviar, which eventually contributed to the gradual extinction of this species in the Danube. The sustainability ethos variable has the smallest value on the vertical axis representing commercial fishing.

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