

Anatomy of cranial nerves in the first Turkish illustrated anatomy manuscript

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Introduction

Teşrih-ül Ebdan ve Tercümânı Kibale-i Feylesûfan was the first Turkish illustrated anatomy manuscript written by Şemseddîn-i İtâkî in the seventeenth century. *Teşrih* is an Arabic word which has various meanings such as dissection of corpse, autopsy, anatomy, and skeleton [1]. This manuscript, the first illustrated anatomy book of Ottoman Period, was written during the period of Sultan Murat IV, who was the sultan of that period [2, 3]. General opinion is that this manuscript was written in 1632 [4–7].

There are very few works which include information only about anatomy in the Ottoman Empire [7]. The information about anatomy was usually found in the other medical books as only a few pages in that period [3]. They are some of the important characteristics of the İtâkî's manuscript that

anatomical terms are expressed in Turkish in that manuscript and the expression is supported by illustrations [6]. This manuscript has led anatomical terms to be made Turkish. In the manuscript, Turkish anatomical terms were written with generally Arabic and rarely Persian equivalents next to them [6, 7].

After a general part following the introduction part, the information was given, starting with bones, about the anatomy of internal organs, nerves, muscles, and vessels, respectively, in the manuscript. The information given about nerves follows the information given about bones differently from the recent point of view. There are original definitions about central and peripheral nervous systems. Firstly, cranial nerves and later spinal nerves were discussed and information was given about points of outlet and distribution regions in the explanations about the nerves [7–9].

Information presented in the manuscript was visualized by anatomical illustrations. Some parts of these illustrations resemble the illustrations in *Teşrihü'l-Ebdan min e't-Tıb* by Mansur (fourteenth century) [2, 7]. Besides these illustrations, there are also some illustrations in the manuscript from various European resources including *De Humani Corporis Fabrica* by Andreas Vesalius. Furthermore, there are some illustrations mostly about nervous system which were drawn by the author himself [6, 7].

The aims of this study are to examine cranial nerves' anatomy in the manuscript *Teşrih-ül Ebdan ve Tercümânı Kibale-i Feylesûfan* written in the Ottoman Period and compare this information in that period with today's knowledge.

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Material and methods

Şemseddîn-i İtâkî'nin Resimli Anatomi Kitabı by Esin Kâhya, which is a translation from Old (Ottoman) Turkish text to contemporary Turkish alphabet of *Teşrih-ül Ebdan ve*

Tercümâmı Kibale-i Feylesûfan, was examined. As well as the parts about Anatomy of Nerves and Cerebral Nerves (Cranial Nerves), the other parts in which the cranial nerves were mentioned were examined. The information in the manuscript was compared with today's knowledge and the correct, imperfect, or incorrect ones were determined.

Results

In the Anatomy of Nerves part of the manuscript, firstly, general information about nervous system was given. After that, cranial and spinal nerves were described separately. Description of nervous system started with the information that the brain was created by God. It was stated that body organs received their strength and feeling from the brain and motor and sensorial features of nerves were described [7].

The author explained the cranial nerves which match the today's knowledge with the statement "God enabled nerves from brain." İtâkî also stated that spinal nerves came out from the spinal cord. He said that the brain would have to be relatively big in order to meet the functions of those nerves if all the nerves came out from the brain. He stated that two problems would occur if all the nerves came out from the brain. The first one, if all the nerves came out from the brain, brain would be big, and thus, it would impose more burdens on the body. Secondly, nerve fibers would be longer, and thus, they lose power on the way to periphery [7].

İtâkî described the cranial nerves as seven cranial nerves and also described each nerve separately. Innervation area of the cranial nerves was expressed as head, neck, and internal organs. Outlets of the cranial nerves were not described in detail; however, they were told to come out directly from the brain [7]. Although some mistakes are seen in the descriptions of the cranial nerves, correct information was given in general. Seven cranial nerves described by İtâkî were examined below and compared with today's knowledge.

1. The first cranial nerve (Fig. 1 (cover figure)) was likened to extensions in nipple form on the front part of the brain and called *Halemetu's sudi* in Arabic. In another part of the manuscript, these extensions were called *hulmetân*. In the manuscript, the ethmoid bone called *mişfât-ı müşakqabe* and filter-like perforated structures on that bone were mentioned. It was stated that the inhaled air passed through these nipple-like holes on the upper side of the nasal cavity and went to the cranium, and smell was felt through the holes on nipple-like nerve extensions in that region [7].

Since this nerve carries the smell to the brain, it can be described as olfactory nerve. Furthermore, it was expressed wrongly that the air reached the cranial cavity after passing



Fig. 1 The first cranial nerve according to Şemseddin-i İtâkî (cover figure)

through the lamina cribrosa and the sense of smell was felt in that region.

Later, it was stated that a nerve exit came out from each extension and separated from each other in a place close to each eye and then entered the eye. The separation place was likened to "X" mark and called *mecma' en-nûr* (optic chiasm) [7]. It is seen here that İtâkî did not regard the first and second cranial nerves as separate nerves but regarded them as a single cranial nerve.

It was stated that the nerves separated from each other on the optic chiasm, and the nerve coming from the right side went to the right eye and the nerve coming from the left side went to the left eye. İtâkî also said "some say that this formation occurs in the way that the nerve coming from right side goes to the left eye, the nerve coming from left side goes to right eye" in the manuscript [7]. It is seen that the functional features of fibers in the optic chiasm could not be known in detail since the structures were only examined macroscopically in that period.

The nerve which entered the eye was stated to end around *ruḩbet-i celidiyye* (lens) which provided vision. The optic nerve was named as *aşab-ı mücevvefe* and said to be the sensory nerve of the eye. While describing this nerve, the word *mücevvef* was used which meant hollow. Thus, we can define this nerve as the optic nerve according to the information provided. However, the vessels in this hollow nerve were not mentioned. It is a wrong description that the nerve fibers ended around the lens.

In the manuscript, benefits of the optic chiasm related to visual function were emphasized. The first one of these benefits is that all the light goes to the healthy eye when one of the eyes is closed, and thus, the strength on that side increases. Other benefits are that the optic chiasm prevents diplopia by

checking the movements of the pupil and the neural transmissions get stronger after the two nerves join on the optic chiasm [7]. These definitions are far from today's knowledge. In conclusion, it is seen that anatomical information about olfactory nerve and optic nerve was given in the first cranial nerve part.

2. The second cranial nerve (Fig. 2) exited behind the first cranial nerve and moved forward the hole on the eyelids, and it reached to the pupil muscles and ended by being divided into six branches. It was emphasized that the movement of the eye was provided by this nerve, and therefore, it was thick. It was explained that the pupils' movement was provided by six muscles, two of which were inclined [7]. We think that the "pupil muscles" term meant the muscles that moved eyeball. Additionally, it was said in the anatomy of the eye part of the manuscript that one of the optic nerves was for sensation (optic nerve) and the other one was for movement. From here, we think that the nerve that moved the eye was the second cranial nerve. We think that the second cranial nerve consisted of oculomotor nerve, trochlear nerve, and abducens nerve. The exit hole of this cranial nerve is probably the superior orbital fissure.
3. The third cranial nerve (Fig. 3) exited in the middle of the brain; a half of the brain was in front of the nerve and the other half was behind it. When this nerve exits from the brain, it joins with the fourth cranial nerve. At the exit point from the brain, the nerve joins with the fourth cranial nerve, and then, it is divided into four branches [7].

(a) *The first branch of the third cranial nerve, which goes out from the hole where uruk-u sibâti has entered,*

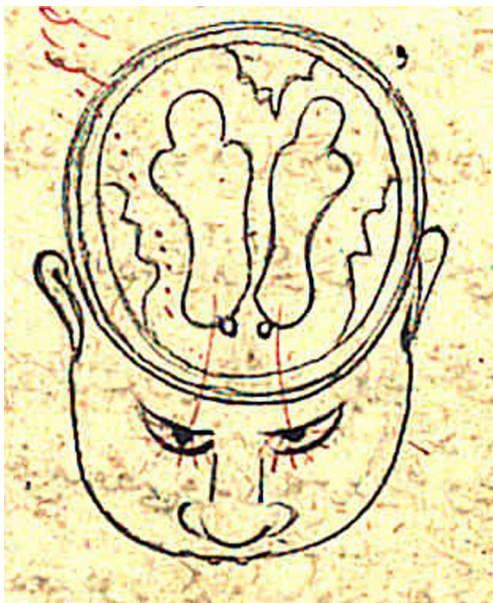


Fig. 2 The second cranial nerve according to Şemseddin-i İtâkî



Fig. 3 The third cranial nerve according to Şemseddin-i İtâkî

goes down to the neck, passes through the diaphragm, and is distributed to the internal organs. Kâhya [7] defined *uruk-u sibâti* as the carotid artery. Because of the course of the first branch, we regard it as the vagus nerve. The information that the first branch goes out from the hole where *uruk-u sibâti* enters is not true. We think that it might have been described as this because of the fact that the carotid artery and vagus nerve go out from two close holes and moved forward in the same sheath.

(b) *The second branch of the third cranial nerve comes out from the temporal bone and joins with a branch of the fifth cranial nerve [7]. Since it was stated that a branch of the fifth cranial nerve and a branch of the third cranial nerve joined and went to the flat muscles of the face, the second branch of the third cranial nerve can be considered as the facial nerve.*

(c) *The third branch of the third cranial nerve went out from the hole where the second cranial nerve went out and then was divided into three branches [7]. We think that this structure, through which the second cranial nerve passed, is the superior orbital fissure.*

- *The first branch of the third branch of the third cranial nerve reaches to temporal muscles and muscles of mastication, to the forehead and eyelid on the ear side of the eye [7]. In the anatomy of lower jaw muscles part of the manuscript, the muscles of mastication were defined, but any information about their*

innervation was not given. We think that the nerve distributed to the region of forehead and eyelid is the frontal nerve. However, the information that this nerve innervates temporal muscles and muscles of mastication is not true.

- *The second branch of the third branch of the third cranial nerve* comes to the edge of the eye on the side of the nose, where the nerve goes into to the nose through a hole and is distributed in the skin inside the nose [7]. According to this definition, we assume that this branch is the nasociliary nerve.
- *The third branch of the third branch of the third cranial nerve* enters into a hole in facial bones, and some of its fibers are distributed to upper jaw and gums. Also, it was stated that some fibers went out and were distributed to the facial skin, the tip of the nose, and the upper lip [7]. We may regard this branch as the infraorbital nerve based on the information given.

(d) *The fourth branch of the third cranial nerve* goes down the hole in the maxilla and is distributed outside the hole. The tongue was stated to feel bitter and sweet tastes through this nerve. Some fibers separating off from the fourth branch are distributed at the bottom of the teeth and lower lip [7]. The course of the fourth branch resembles the course of the greater palatine nerve. However, the information that the tongue receives the senses of tastes through this nerve is not true. Any hole in the maxilla was not mentioned in the other parts of the manuscript. In our opinion, this hole may be the greater palatine foramen. The nerve going down the maxillary bone is compatible with the greater palatine nerve, which passes through the greater palatine foramen on maxilla. Although innervation area of the mandibular nerve was described, any information about the origin of the mandibular nerve was not given.

4. The fourth cranial nerve (Fig. 4) comes out from the behind of the third cranial nerve and joins with this nerve at the inner side of peak [7]. This nerve was stated to reach to nasal passages and lead to sense of smell. However, any nerve reaching the peak was not mentioned in the part of the manuscript in which the third cranial nerve was mentioned. We do not think that this nerve said to receive its sense of smell from nasal passage is compatible with any nerve.
5. The fifth cranial nerve (Fig. 5) was stated to come out from both sides of the brain, and each branch of it was divided into two branches [7].

(a) *The first branch of the fifth cranial nerve* is distributed to tympanic membrane inside the ear and enables hearing [7]. Since this branch receives the sense of



Fig. 4 The fourth cranial nerve according to Şemseddin-i İtâkî

hearing from the ear, we think that it is the cochlear nerve. But, receiving the sense of hearing from the tympanic membrane is not compatible with today's knowledge.

(b) *The second branch of the fifth cranial nerve* came together with the hole called a 'ver or a 'ma in the pyramidal part of the temporal bone and joined with the third cranial nerve, which went upward through the same hole and then moved the flat muscles of the face. It was previously stated that the second branch of the third cranial nerve (list 3 (b)) comes out from the hole of the temporal bone (probably *stylomastoid foramen*) and joins with the branch of the fifth cranial nerve [7]. We think, especially based on the information that the nerve moves the flat muscles of the face, that this branch is the facial nerve.

6. The sixth cranial nerve (Fig. 6) was stated to come out from the back of the brain behind the fifth cranial nerve. It was explained that tympanic membranes and ligaments covered the fifth and sixth cranial nerves together and these two nerves look like a single nerve. The sixth cranial nerve is divided into three branches on each side, and these three branches come out from two holes at the end of the lambdoid suture [7]. These holes can be considered as the jugular foramen. Additionally, although the lambdoid suture was explained at the part of skull holes, holes at the end were not mentioned.



Fig. 5 The fifth cranial nerve according to Şemseddin-i İtâkî

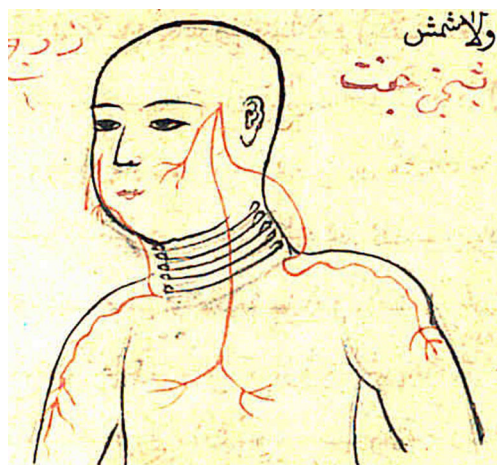


Fig. 6 The sixth cranial nerve according to Şemseddin-i İtâkî

(a) *The first branch of the sixth cranial nerve* was said to go to pharynx muscles and tongue base [7]. We think that this branch is compatible with the glossopharyngeal nerve.

(b) *The second branch of the sixth cranial nerve* was stated to reach the scapula muscle and the flat muscle at the back of [7]. We think that this branch was the spinal roots of accessory nerve which innervated the trapezius muscle.

(c) *The third branch of the sixth cranial nerve* was stated to be bigger than the other branches. It was described that this branch went to the abdominal and thoracic organs. This branch goes down the hole from where the carotid arteries come out and the carotid artery reaches to the muscle, the head of which is upward. Later, this branch passes the larynx and reaches the chest. Some branches, which are separated from that branch in the chest, return and reach the muscles of arytenoid cartilages called *tırchâlî*. These branches are called *aşabî ric*. The rest of this branch heads downwards and is separated on the diaphragm, pectoral muscles, heart, liver, lung, and cardiac arteries and veins. Lastly, it was explained that this branch passed through the diaphragm and joined with the third cranial nerve and then was distributed to the internal abdominal organs and intestines [7]. Based on the distribution area of this branch, it can be considered as the vagus nerve. Since this branch courses with the carotid artery in the neck region, İtâkî might have thought that this branch went out from the hole from which the carotid artery went out. İtâkî also described the recurrent laryngeal nerve. İtâkî stated that the fifth and the sixth cranial nerves were covered with a common sheath. The statement that the fifth and the sixth cranial nerves are covered by membranes and ligaments is not true.

7. The seventh cranial nerve (Fig. 7) was stated to come out between the brain and the spinal cord. Several branches separating off from the nerve were told to go to the muscles that moved the tongue. It was stated that some branches separating off from the nerve reached the hyoid bone, while some branches reached muscles between *derekî* (thyroid cartilage) and the hyoid bone and were distributed between the muscles [7]. According to this definition, this nerve can be said to be the hypoglossal nerve. We think that the branches of some fibers of this nerve which go to infrahyoid muscles may be related to ansa cervicalis.

Discussion

Teşrih-ül Ebdan ve Tercümâm Kibale-i Feylesûfan is one of the rare works of art written in the field of anatomy during the Ottoman Period. İtâkî was influenced by the works of Islamic medical scholars as well as many European scholars, which were written before he wrote this manuscript. Adivar [2] said that İtâkî’s most important source was *Teşrihü’l-Ebdan min e’t-Tıb* written by Mansur in Persian although İtâkî did not express it clearly. Kâhya [7] stated that this is not true when both works of art are compared. Kâhya [7] emphasized that İtâkî’s work has six times more volume than Mansur’s and the subjects are also explained in a more detailed way in the İtâkî’s manuscript. The other Islamic medical scholars whose works of art İtâkî benefited from are Ali ibn Abbas, İbn-i Nefis, Ebu

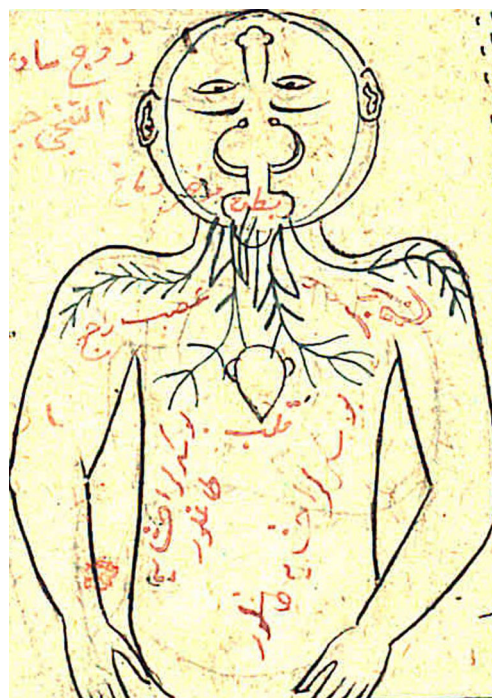


Fig. 7 The seventh cranial nerve according to Şemseddin-i İtâkî

Table 1 The evaluation of the cranial nerves identified by Ītâkî according to different authors

Ītâkî (7)		Present study	Ulucam et al.(11)	Kâhya (7)	
1st CN		Olfactory nerve Optic nerve	Olfactory nerve Optic nerve	Optic nerve	
2nd CN		Oculomotor nerve Trochlear nerve Abducens nerve	Oculomotor nerve Trochlear nerve Abducens nerve	Oculomotor nerve Trochlear nerve Abducens nerve	
3rd CN	1st B	Vagus nerve	Vagus nerve	Trigeminal nerve Facial nerve Vagus nerve	
	2nd B	Facial nerve	Facial nerve		
	3rd B	1st B	Frontal nerve		Ophthalmic nerve Maxillary nerve
		2nd B	Nasociliary nerve		
		3rd B	Infraorbital nerve		
4th B	Greater palatine nerve Mandibular nerve	Mandibular nerve			
4th CN		-	Mandibular nerve	Motor branch of trigeminal nerve	
5th CN	1st B	Cochlear nerve	Vestibulocochlear nerve	Cochlear nerve	
	2nd B	Facial nerve	Facial nerve	Facial nerve	
6th CN	1st B	Glossopharyngeal nerve	Glossopharyngeal nerve	Glossopharyngeal nerve Vagus nerve Spinal root of accessory nerve	
	2nd B	Spinal roots of accessory nerve	Accessory nerve		
	3rd B	Vagus nerve	Vagus nerve		
7th CN		Hypoglossal nerve Ansa cervicalis	-	Hypoglossal nerve	

Bekir er-Razi, and Ībn-i Sina [2, 4, 7, 10]. The other medical scholars, from whom Ītâkî was influenced, are Aristo, Galen, and Andreas Vesalius [7, 11].

The basis of the numbering of the cranial nerves in pairs as used today dates back to the first century. As its initial form, the cranial nerves were said to be seven pairs. This definition

of Galen, who quoted from Marinus from Alexandria, lasted until the seventeenth century; in this century, Willis identified nine pairs of cranial nerves. With the system put forward by Von Soemmerring in the eighteenth century, cranial nerves were evaluated to be 12 pairs. However, it was not until the end of 1800s that today's numbering started to be used widely

by all the anatomists of the time [12]. İtâkî defined the cranial nerves as the nerves that came out from the brain, and they were stated to be seven pairs [7].

It is seen that İtâkî did not define clearly and truly the exit points of cranial nerves from the brain. For example, the second cranial nerve was said to come out from the behind of the first one, while the exit point of the first cranial nerve was not identified. The similar situation applies to the other cranial nerves. Although the cranial nerves can be observed macroscopically during the cadaver dissection, İtâkî could not give detailed information about the settlements of the cranial nerves in the brain. We think that it is because the cadaver dissection could not be carried out in that period.

Branches of the cranial nerves and the courses of these branches are not clearly and explicitly defined in the manuscript. There is incomplete and incorrect information about the holes and channels through which nerve passes during its course, the nerve neighborhoods, the progress of the nerve, and the anatomical structures that nerve goes to. This situation makes it difficult to interpret the nerves with the current knowledge.

Another deficiency observed in the manuscript is that the integrity of information cannot be provided between the cranial nerves. For example, in the fifth cranial nerve, a branch was said to join with the third cranial nerve. However, it was not stated which branch of the third cranial nerve it joined with. Moreover, the fourth cranial nerve was told to join with the third cranial nerve around the parietal bone, but there is not such information in the part of the third cranial nerve. The third branch of the sixth cranial nerve was stated to join with the third cranial nerve. However, such a joining was not mentioned in no branches of the third cranial nerve.

There is also contradictory information in the İtâkî's manuscript. A cranial nerve was seen to be described in more than one cranial nerve. For example, the vagus nerve was described in both the third and the sixth cranial nerves.

In this study, the cranial nerves defined by İtâkî are compared with the current knowledge by taking into account the studies which were done previously (Table 1).

The first cranial nerve is related to smell and vision. Kâhya [7] ignored the relationship of the first cranial nerve with the smell and stated that it contained only the optic nerve. Like Ulucam et al. [11], we also think that, because of the smell and vision features of this cranial nerve, it contains both olfactory and optic nerves. It was suggested in the previous studies that *Halemetu's sudi* corresponded to olfactory tract [7, 11] and *hilmotan* corresponded to olfactory lobe [7]. We think that it would be truer to call these apophyses as olfactory bulb.

Since *the second cranial nerve* is related to the movements of the eyeball, we think that this cranial nerve covers oculomotor, trochlear, and abducens nerve as stated in the previous studies [7, 11].

The third cranial nerve is a nerve which has many branches. According to Kâhya [7], this cranial nerve consists of trigeminal, facial, and vagus nerves, but he did not state which branch includes which nerve. When examining the course of branches of the nerve, it is possible to define these branches in a more detailed way. Accordingly, we think that the terminal branches separating off from the third branch of the third cranial nerve consist of frontal, nasociliary, and infraorbital nerves. While İtâkî described the fourth branch of the third cranial nerve, he stated the innervation area of the mandibular nerve but gave false information about the origin of the mandibular nerve. While Ulucam et al. [11] considered the fourth branch of the third cranial nerve as the mandibular nerve, we think that the distribution area of this nerve complies with the mandibular nerve, and the course of this nerve is compatible with the greater palatine nerve (Table 1).

In the manuscript, it was stated that the *fourth cranial nerve* received the sense of smell from the nasal passage. It was stated in the previous studies that this nerve might be the mandibular nerve [7, 11]. Since the mandibular nerve is not the nerve that receives smell from nasal passage, this definition is not true in our opinion. We do not think based on the current knowledge that the fourth cranial nerve has an equivalent.

It was stated that the branches of the *fifth cranial nerve* are vestibulocochlear and facial nerves, respectively [11]. İtâkî emphasized only the hearing feature of a branch but did not give any information about the balance in the manuscript. Therefore, we think that it would be truer to define this branch as the cochlear nerve. There is a consensus that the other branch is the facial nerve.

It was stated in the previous studies that the first, second, and third branches of *the sixth cranial nerve* might be glossopharyngeal, accessory, and vagus nerves, respectively [7, 11]. Our opinion is also in this direction. It was stated wrongly that the branch forming the vagus nerve innervated the diaphragm.

Kâhya [7] identified the seventh cranial nerve as the hypoglossal nerve since it moves the tongue. However, Ulucam et al. [11] did not express any opinion about this nerve. We consider this nerve as the hypoglossal nerve. Furthermore, it is also mentioned that it contributes to the formation of ansa cervicalis which innervates the infrahyoid muscles.

Conclusion

Şemseddin İtâkî's manuscript entitled *Teşrih-ül Ebdan ve Tercümânî Kibale-i Feylesûfan* is seen to have a distinctive place in the history of Turkish anatomy and has a preliminary role on anatomical terminology to be made Turkish. The information about anatomy in previous periods is thought to contribute to the development of anatomy, despite their shortcomings and mistakes. In addition to these, it is also useful to

know the works of art in this category for the sake of protecting the Anatolian culture and scientific heritage.

Acknowledgments The all figures used in the text were taken from the permission of the Süleymaniye Library Istanbul, Turkey (Collection of the Hüsrev Paşa 464).

Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

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