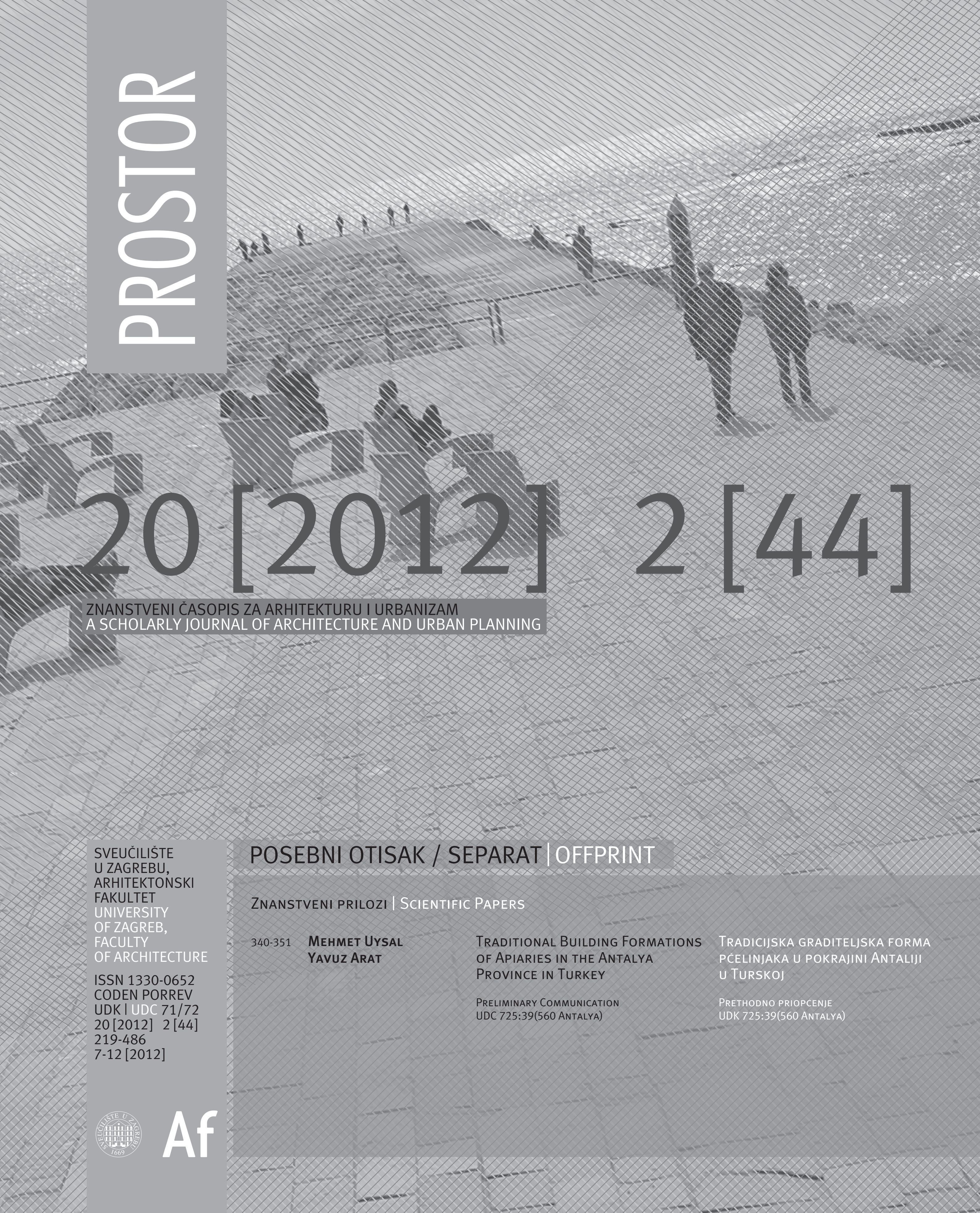

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Yavuz Arat

Traditional Building Formations of Apiaries in the Antalya Province in Turkey

Preliminary Communication
UDC 725:39(560 Antalya)

Tradicijska graditeljska forma pćelinjaka u pokrajini Antaliji u Turskoj

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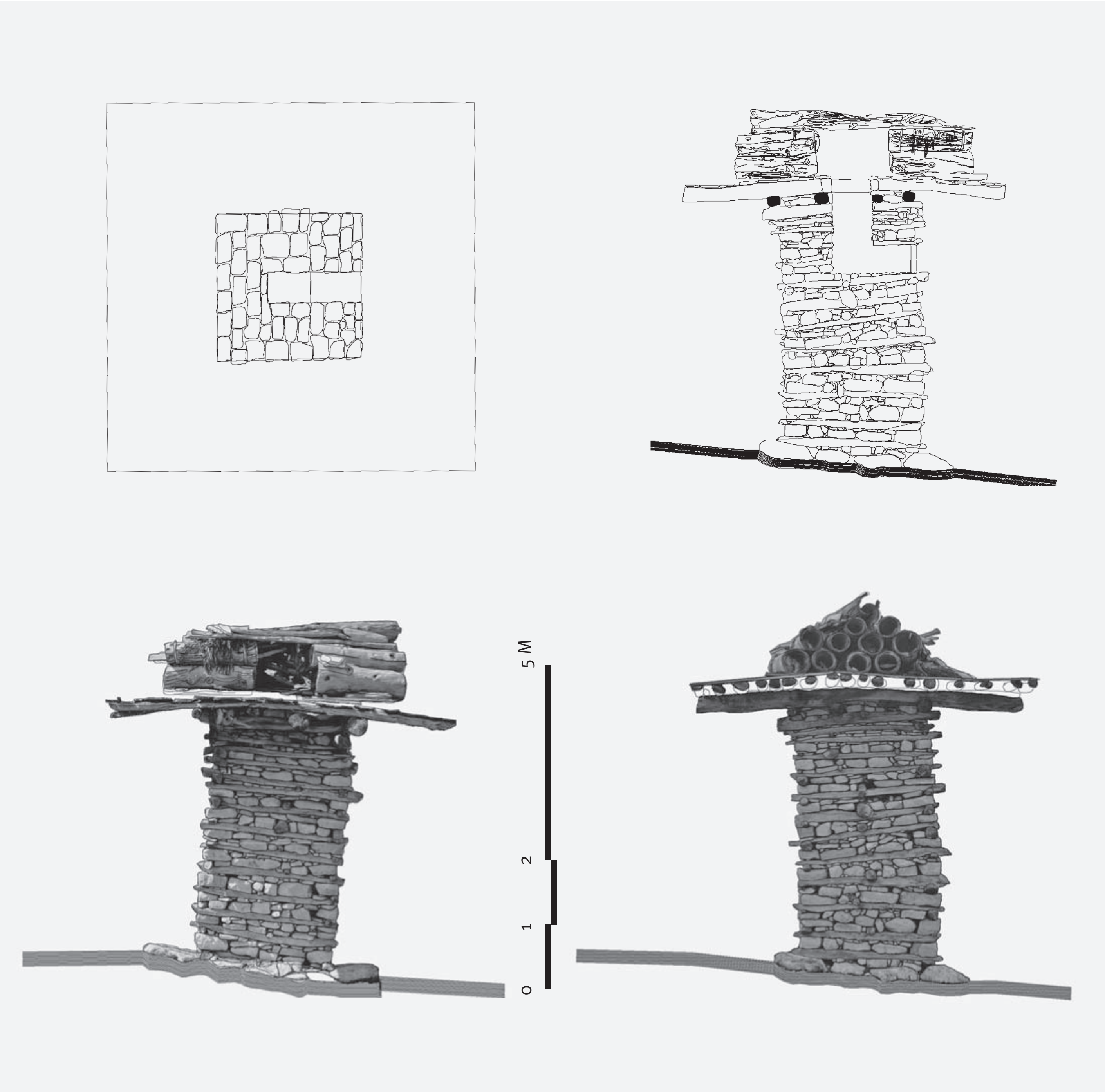

Fig. 1. The formation of bee yards (Ari Serenleri): plan, section and elevations
Sl. 1. Formacija pćelinjaka (Ari Serenleri): tlocrt, presjek, pogledi

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Traditional Building Formations of Apiaries in the Antalya Province in Turkey

Tradicijska graditeljska forma pčelinjaka u pokrajini Antaliji u Turskoj

Ecological design
Elmali, antalya, turkey
Shelters
Symbolism
Vernacular architecture

ekološko projektiranje
Elmali, Antalija, Turska
zaklonište
simbolizam
tradicijska gradnja

In this paper, "bee yards" are studied in view of the relationship between vernacular architecture and biomimicry. The bee yards, as architectural forms of vernacular architecture for animals, are located around Elmalı district of Antalya. This study aims to investigate how much the natural elements and ecological system of the honey bee affect the formation of bee yards. Analyses of biomimicry measures (on the organism level, behavior level, and ecosystem level) as determined by Maibritt Pedersen Zari in 2007 were conducted in order to illustrate this phenomenon.

Ovaj se rad bavi analizom pčelinjaka sa stajališta odnosa tradicijske gradnje i biomimikrije. Pčelinjaci, kao primjeri graditeljskih formacija tradicijske arhitekture za životinje, smješteni su u okolici okruga Elmali u provinciji Antaliji. Cilj je rada ispitati u kojoj mjeri prirodni elementi i pčelinji ekološki sustav utječu na formiranje pčelinjaka. Analize biomimikrijskih mjerenja (na razini organizma te na bihevioralnoj razini i na razini ekosustava) prema Maibritt Pedersen Zari (2007.), provedene u ovome radu, imaju za cilj pojasniti ovaj fenomen.

Introduction

Uvod

Agriculture is the most important element in the process of laying the foundation for human settlement and civilization. Human settlement and civilization process has developed hand in hand with the development of agriculture. A process of cultivation was applied to both vegetal and animal species. As a result of the habits of pre-agricultural society, expandable vegetables were gathered from nature and selection was applied to breedable species. The above-defined process is still used in agriculture. A similar approach was applicable for animals, as well. For instance, the animal species that are useful for human beings were domesticated. In this scope, the necessity of building animal shelters to protect them from environmental conditions was an essential requisite of settled life. It can be seen that all animal shelters are formed according to local characteristics and ecological environment. Human beings learned to take honey from the natural haunts of honeybees during the period when they fulfilled their food needs by gathering from nature. Apiculture (bee-keeping) was started by humans taking honey without killing bees living in tree cavities and leaving some honey in the haunt for the bees. The Bogazkoy excavations in Anatolia showed that apiculture was an important agricultural activity during the Hittite civilization in B.C. 1300. Moreover, during those times the honey produced by bees had a religious value and was accepted as holy. It had a symbolic meaning in many societies and took place in sacred books like the Bible or the Quran. It was determined that Turks used honey and honey products and accepted it as a sort of medicine and a healing food during the nomadic period. According to Mahmud from Kashgar, Turks first named honey as "honey oil", and then Western Turks in particular (Oguzs, Kıpcaks, Suvars) called it honey. Uygurs called honey "mir". Also, it is known that there were arrangements for apiculture during the Ottoman Period.

The real aim in building shelters for honeybees is to provide protection from natural elements and from animal harm (e.g., bears, etc.). The "Arı Serenleri (Bee Yards)" have a unique formation as an architectural element in the ecological system located in Söğle Plateau in Elmalı County of Antalya province in Turkey. Such building formations are widely seen in this region which has been one of the important centers for honey production since time immemorial. These are the only examples of the mentioned architectural structures in Anatolia. Numerous researches have put forward that the architectural origins of bee yards date back to ancient times yet these arguments based on formal similarity are not satisfactory. Inspired by nature every society has created its own unique architectural formation. In this scope, it is thought that the hexagonal comb texture formed by the bee can be active on the upper formation of the yards and the live honey bee ecosystem is continued in the natural environment. In this study, the examples of bee yards are analyzed according to the mimicry measures determined by Zari (2007). As a result of this analysis it is seen that there is no element of mimicry on the level of the organism; the mimicry element is related to the upper structure of the bee yards only from the point of the form on a behavioral level and it is related to form, material, construction, process and function on the ecosystem level. In order to make their lives easier mankind observed animals and plants and constructed their environment in their likeness. Although biomimicry is a recent concept that emerged during the last two decades, it is known that there are examples of this in history. Human beings were first inspired by the structures created by plants and animals and they used them – and this was not limited to similarity. With the agricultural society human beings developed environmental and settlements

1 Oliver, 2003
2 Kalayci, 2010
3 Arslan, Sorguc, 2004
4 Mosseri, 2004
5 Goss, 2009
6 Arslan, Sorguc, 2004

patterns based on nature. These formations are exposed in local environments as vernacular beginnings since earliest times. These formations in rural areas and the natural environment made use of natural conditions and living examples (plant, animal, etc.). Today there is an increase in the production of architectural structures built according to engineering rules by technical staff. However, the vernacular makes up 90 per cent of the world's buildings and comprises approximately 800 million dwellings.[1] These local architectural formations include both human and animal shelters.

Throughout history mankind was inspired by nature. The traits of this inspiration might be observed on columns, ornamentations and other architectural elements of ancient times and is embodied in many architectural movements developed during and after the industrial revolution. John Smeaton's Eddystone lighthouse tower (1759) is the first example inspired from nature in recent eras. Many architects, such as Antoni Gauidi in the 19th century and Hans Poelzig, Eric Mendelson, Bruna Taut, Walter Gropius, Frank Lloyd Wright, and Santiago Calatrava in the 20th century made use of nature and expressed themselves in different designs.[2]

Biomimesis, Biomimicry and Biomimetics

Biomimesis, Biomimikrija i Biomimetika

Human beings, from the very beginning, have had a tendency to discover and learn from their environment. In their observation/learning/designing process, they have experienced adaptation and developed skills to provide for their needs by imitating, interpreting, and using the opportunities provided by nature.[3] In general, human beings succeeded in using many of the structural principles that exist in nature. In cases of extreme structural projects, the connection between nature and man-made creations is relatively high.[4] Human beings have always looked to nature, especially objects of living nature, as a design model and source of inspiration.[5]

Since 1998, the term "biomimesis" (bios, meaning "life", and mimesis, meaning "to imitate") has been employed in studies to provide clues and answers to what men need by observing and analyzing nature. Although biomimesis is considered as a formal field of science in the 20th century, its principles and concepts have been recognized for a long time. The first concise examples date back to the medieval period, to Da Vinci's studies on subjects from mechanisms to medicine.[6] "Biomimesis", the imitation of animate and inanimate forms from nature to inspire new designs, was introduced as a term at the end of the 20th century.

Since that time, the way of inspiring/learning/adapting and/or implementing processes from nature and the conception of how to employ these processes in different information/technology fields have been discussed systematically.[7]

These learning, adaptation and designing processes resulted in a new field of science: biomimesis, the study of nature's best ideas in order to imitate these designs and processes to solve "our" problems, ranging from manufacturing to medicine, from engineering to information technologies.[8] It is seen with applied examples that the natural adaptation developed by nature and living creatures against existing conditions in an area affects the architectural design, ecology and sustainability of humans in that area.[9]

Biomimetics can essentially be defined as the practise of "reverse engineering" ideas and concepts from nature and implementing them in a field of technology such as engineering, design or computing – for example, the development of machines that imitate birds, fish, flying insects or even plants.[10] Biomimicry, biomimesis, biomimetics, bioinspiration, and bionics are the somewhat indistinguishable fields of study dealing with new technology and design strategies based on existing natural systems. Biomimetics include a natural model, a translation, and an artificial product.[11] Transfers from living nature make sense because natural models have come into being through the process of evolution, and have been subjected to many different conditions.

They therefore represent extremely complex solutions, and their translation is not merely a matter of form.[12] Interdisciplinary work is essential for the investigation and the design of natural constructions. Basic biological research must form the foundation for biomimetics.

Interdisciplinary working methods are required from both sides: the discipline delivering research and the discipline dealing with applications. To this end, the linguistic barriers between the disciplines must be overcome. For this reason, the study of biomimetics includes both life sciences and engineering. Analogies serve as a starting point for bionic translation.

7 Arslan, Sorguc, 2004
8 Benyus, 1997
9 Yesilli, 2010
10 Ayre, 2004
11 Wiebe, 2009
12 Gruber, 2011

Common features connect elements of nature or technology. Frei Otto distinguishes between analytic and synthetic approaches to analogy research.[13] Abstraction is the key to transferring ideas from one discipline to another. Thus, models are abstractions from nature. Architects and builders have always drawn inspiration from nature. Countless analogies can be found in the architecture of all ages. [14]

In human history, research in geometry takes a central place between other scientific developments. People became interested in Complex Geometry in order to copy "perfect" natural shapes like crystals. More importantly, that simple geometry turned out to be insufficient for establishing innovative design.[15] The origin of geometry goes back to religious rituals and mankind has used divinely inspired geometry for centuries. Certain specific ratios can be found in the design of life forms in nature.[16] The golden ratio and Fibonacci spiral derived from nature are used in ornamentations and architectural formations in many cultures from east to west. Throughout the centuries, builders and craftsmen of ancient structures have used nature as their guide to proportion their buildings for aesthetic and structural purposes. As modern structural analysis methods evolved, the necessity of considering structural proportions based on what was observable in nature all but disappeared.[17] Critics and philosophers since ancient Greece have looked to natural organisms as offering perfect models of that harmonious balance and proportion between the parts of a design which is synonymous with the classical ideal of beauty.[18] We now come to a second way in which a biological or 'organic' method of design might seek to escape the problem of the excessive amount of time involved in mimicking the natural evolutionary process. This is to be found in the concept of 'biotechnique' or 'biotechnics', which attracted some interest amongst designers in the late 1920s and 1930s. In essence, the proposal was this: in the evolution of plants and animals, nature herself had already made a great variety of 'inventions', embodied in the designs of organs or in the adaptations of the limbs, and so modern inventions should follow these designs.[19]

Janine Benyus' book "Biomimicry: Innovation Inspired by Nature" published in 1997 refers to a new scientific field that studies nature, its models, systems, processes and elements, and then imitates or takes creative inspiration from them to solve human problems sustainably.[20] Living things, furthermore, have evolved under pressure to succeed at reproduction. Buildings, by contrast, are free from the burden to reproduce and self-repair which, in itself, is quite liberating. This allows for great simplicity and innovation. Buildings so conceived are thus able to express an idea, or signify a meaning or a concept beyond their basic function. Today, biomorphic architecture reflects more and more the destitution of human meanings. The structures of today's buildings refer to animal and plant forms.[21] The scales, functions, and processes that are observed in nature can be different, but the constraints and objectives are very similar with what we have to provide in all the designs: functionality, optimization, and cost effectiveness. Therefore, it is not surprising that mankind has always admired biological structures and has often been inspired not only by their aesthetic attributes but also by their engineering and design qualities and efficiencies.[22]

This article explains how biomimetics for design and digital production can integrate procedures to conceive, visualize, generate, and model architecture by studying forms and processes in nature and how that process has evolved in Dollens' work. Looking to seeds, plants, diatoms, algae, shells, etc., for biomimetic information suitable for design extrapolation to new architectural forms, the presentation considers how sustainable environments could be integrated with technical innovation, new attitudes toward genetics, biomaterials, and science/design collaboration.[23] Biomimicry makes sense. Since time immemorial nature has been struggling with many of the same problems we now face (structure and support, coloring, heating and cooling) and has developed the most energy – and materials – efficient design solutions in order to survive. Whether we are designing or specifying building materials (e.g., insulation, interior and exterior color, fire protection, waterproofing) or building systems and processes (e.g., temperature regulation, fresh air, water supply, and cleaning) we can learn from nature.[24] A tremendous database of natural solutions is all around us, but to access it we need to pose the right questions and frame them in a way that biologists – the keepers of the database – can understand.[25]

Including traditional architecture in the definition of "natural constructions" means that traditional building technologies can serve as a source of innovation in the same way as bi-

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13 Gruber, 2011
14 Gruber, 2011
15 Tomlow, 2004
16 Hejazi, 2004
17 Rosson, 2004
18 Steadmen, 2008
19 Steadmen, 2008
20 Goss, 2009
21 Goss, 2009
22 Arslan, Sorguc, 2004
23 Dollens, 2006
24 Koelman, 2004

ological role models do.[26] Traditionally, locally available resources are used for building, and typologies evolve with time, more through trial and error than through abstract modeling of some sort. The influencing factors for the design are the existing environment and the social and cultural situations. Environmental issues include the availability of space, building materials, energy, climate and ecology, among others. Social and cultural situations include knowledge and available technology, the needs of society and culture, symbolism, rules, etc. Within the existing typologies, diverse influences from a wide time span have been applied and stored, and much is still readable today, even if the developmental processes and environmental conditions of former times are not known. But the end product, the surviving typology, is to be investigated here. The knowledge needed to build this kind of architecture is usually passed on by local tradition. The term ”vernacular” architecture is mainly used for residential buildings, excluding temples and palaces. Yet, as constructions for bigger building tasks also deserve investigation, ”traditional architecture” is the term used here.[27] In the context of bionics and biomimetics, the ”evolution” and ”adaptation” of traditional architecture is most interesting. The inherent qualities and the integrated information of traditional typologies can deliver priceless hints and solutions when properly investigated and interpreted. The importance of traditional architecture as a source of innovation is inadequately identified and used. Most old architectural typologies which have survived to the present day are not adapted to the requirements of a modern civilized life. For this reason, a simple ”back to the roots” approach would certainly not be appropriate.

The qualities and information found in tradition have to be applied to an independent, new solution. The transformation process, which inevitably needs to take place when using principles coming from tradition, is similar to the one used with biological role models. Abstraction and separation from the role models must be found in order to develop a contemporary and modern solution. The independence of the new design is of utmost importance.

Many architects and researchers have sensed the importance of vernacular architecture, and have focused on this field. The most well-known, due to impressive photographic documentation, is Bernard Rudofsky’s work on anonymous architecture, published first in ”Architecture without Architects” in 1964. Rudofsky has made architectural traditions from around the world known to a wider audience.[28]

Bio-inspiration, on the other hand, implies transferring new qualities and strategies inspired by nature to the culture of design, via an abstraction process. This process requires establishing a correlation by analogy between the design issues to be addressed and the solutions offered by nature.[29] As the science that studies nature’s best ideas and imitates these designs and processes to solve human problems, biomimicry can help to significantly reduce the environmental impact of projects and to define a new sustainable standard for the design and construction professions.[30] In the future, the houses we live in and the offices we work in will be designed to function like living organisms, specifically adapted to their physical location and able to draw all of their requirements for energy and water from the surrounding sun, wind and rain.[31]

Study Area and Analyses

Područje istraživanja i analize

Elmalı, in the western Mediterranean Region in Antalya, on the mountains of South-western Taurus, is a precious residential area that protects its traditional structure. The earliest settlements in Elmalı and its neighborhood date back to ancient times (B.C. 5-4 Lycia). After Anatolia was Turkicized and the Tekeli Turk clan settled there, the city formation showed the improvement of Seljuk State and especially Ottoman administration in XVI Century.[32] Elmalı is a historically and culturally important center. Around Elmalı are the antique cities of Balbura, Ayvasıl, Elbessos, Arneai, Podolia, Khomaand Müğren Tumulus, Sematumulus, Karataş-Sematumulus, Beyler Tumulus, Gilevgi Tumulus, Akçay Tumulus, Tekke Tumulus and Söğle Tumulus. Also located in this region are Bayındır Tumulus, many monumental tombs and the Elmalı treasure, which have a worldwide reputation.[33] Tumuluses and classical settlements obviously show that the Elmalı Plateau saw dense settlements from the Neolithic period until today.[34] There are also examples of civil architecture and monumental artworks in Elmalı. Transhumance continues in the Elmalı Region as a Turkish tradition. One of the most important plateaus is Söğle plateau.[35] Asarlık Tepesi near Söğle, apparently was settled

25 Koelman, 2004
26 Gruber 2011
27 Gruber 2011
28 Gruber, 2011
29 Santulli, Langella, 2010
30 Drucker, 2011
31 Berkebile, Mclennan, 2004
32 Akçay, 1966; *** 2010; Ceylan, 2007; Duymaz, 2008; Oktaç 2004; Serbest, 2008
33 Serbest, 2008
34 Çevik, 1996
35 Serbest 2008

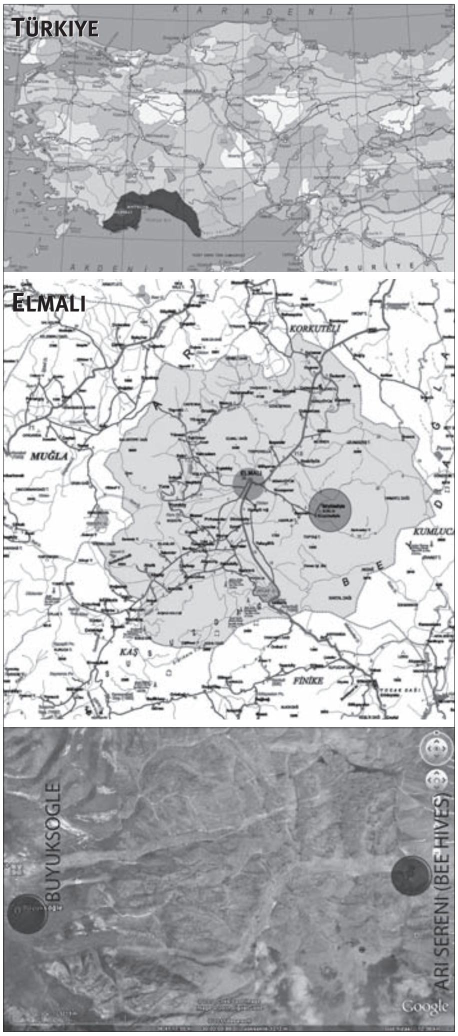

Fig. 2. Location of the formation of bee yards in the Elmali county within in the Antalya province
Sl. 2. Lokacija formacije pćelinjaka u okrugu Elmali u pokrajini Antaliji

towards the mid-fourth century B.C., heading a new wave of settlement across the basin (Küçük Söğle is dated to the late Hellenistic period (2-1 B.C.) and Büyük Söğle and is dated early Roman (1 A.D.).[36] There can no longer be any doubt about the locations of Lykia settlements at, for instance, Podalia (buralye), Soklai (Söğle) and Akarassos (Elmalı).[37] The Söğle villages (both Büyük Söğle and Küçük Söğle) which mark our study area are approximately 12 km away from the Elmalı district. These villages are famous for honey because of the bee yards. There are bee yards in the plateaus of many Söğle villages (Serkis Area, Gölalanı, Çakşır Dibi). It is known that the bee yards were built until the 1970s.

Elmali Ari Serenleri (Elmali Bee Yards)

Elmali Ari Serenleri (pčelinjaci u Elmali)

Beekeeping has been popular in Turkey since the ancient times of Anatolian civilizations, Seljuk's State, Anatolian Turks Principalities and the Ottoman State.[38]

The first scripts about beekeeping were found at a Hittite period of Boğazköy near Çorum, dating back to 1300 B.C. Anatolia was a leader of Mesopotamia in beekeeping and producing honey, like selling wine. In archaic times, the bee figure was used as a decoration on money, tools, sculpture and ornaments. Beekeeping was also important in the Ottoman Empire. Ottoman Emperors such as Fatih Sultan Mehmet, Kanuni Sultan Süleyman and Yavuz Selim gave rules in their codes of law about beekeeping.[39]

Beekeeping is possible within all seven geographical regions of Turkey. Climatic and environmental conditions were always very suitable for practicing the art of rearing bees.[40] Turkey has great beekeeping potential, having very rich flora and a suitable ecology.[41] Just now, it is supposed that there are about 4.3 million honeybee colonies on Turkish soil, and these produced 65,000 tons of honey per year. Turkey is in the third place for honeybee potential and in fourth place for honey production worldwide.[42] In the Mediterranean Region, apiculture (bee-keeping) is densely seen in Antalya. Antalya is an important apiculture center with its climate, geographical structure, plantation variety and ecology.[43]

Anatolia is one of the oldest and most widespread centers where apiculture is seen in the world. The geographical location, rich flora, different vegetation types and climatic properties of Turkey allowed apiculture to flourish and continue in an improved way.[44]

In Antalya province, Kumluca, Alanya, Elmalı, Kaş counties are on the first rows according to the number of the honeybee colonies.

Elmalı is an important center of honey production with the large number of bees inhabiting the area and the amount of pine honey produced which it owes to the generous characteristics of Elmalı plateau and the remarkable richness of the flora.[45] In the Elmalı region, the highest flora capacity is 3000 in Büyüksöğle and 2800 in Küçüksöğle.[46] Because of this characteristic, Elmalı has happened to be one of the important apiculture centers in history. The best indicator of this is the bee yards located here.

Man's first interactions with honey bees (*Apis* species) involved harvesting honey combs from bees' nests in woods and rocks, as shown in prehistoric rock art found in Spain, Africa and India. Gradually, in some areas, people learned how to tend the bees in these natural nests, and finally they developed the skills needed to keep bees in hives, near their dwelling houses.[47]

Arı Serenleri (Bee Yards): In some regions around the Söğle Plateau, there are accumulated black beehives on a platform placed on a tower. This formation is called a bee yard. The body of the bee yard is built as a dry wall with dense beams and the height is between 5-10 meters. The platform on top of this structure is formed of wooden beams, projects out on four sides and is seen in the eave formation. The black beehives on top of these platforms are formed by carving out the inside of tree trunks and arranging them on top of each other in the form of a triangle.[48]

Like many other types of old world architecture, this Anatolian beehive is closely related to funeral monuments; its shape echoes Lycian pillared tombs. The 14-foot-high pedestal puts the honeycombs beyond the reach of human and animal looters. (The platform is reached through a shaft within the pillar.)

Hollow tree trunks, covered with wooden shingles and bark, shelter the bees.[49] The relation between Lykia graves and dwelling formations is firstly told by Ch. Fellows, then O. Benndorf and G. Niemann.[50] It is said that the yards endured till the 17th century,

36 Foss, 2005
37 Foss, 2005
38 Senocak, 1988
39 Kösoğlu, Yücel, Yilmaz, 2009
40 Akbay, 1986
41 Sirali, 2002
42 *** 2011; Gülpinar 2000
43 *** 2011
44 *** 2011

FIG. 3. AREA OF THE FORMATION OF BEE YARDS (ARI SERENLERI)

SL. 3. PODRUČJE FORMACIJE PČELINJAKA (ARI SERENLERI)

and that they are inspired by Lykia grave monuments.

The necessity of building these structures functionally is also emphasized. The last examples of bee yards can be seen in Serkiz Plateau, southeast of the Söğle Village 11 km away from Elmalı, and on the other plateaus of Korkuteli İmecik Susuzu, Saklıkent Yazır Güzlesi, Kumluca Çakmak Plateau, the foot of Göldağ and the foot of Ziyaret Hill on the Bey Mountains.[51]

Beginning with these formations, Rudofsky said there is a relationship between the Lykia grave monuments and the bee yards. However, the necessity of these formations forming the essence of the vernacular architecture to fulfill a function complete with a physical, social and natural environment advances beyond its form. The reason for locating this building type in this region is the richness of the local flora. This formation does not belong to the ancient periods but comes from the Ottoman period. The protection from wild animal and human harm advances in this formation. An additional function is its height, which is appropriate for bees to fly in easily. Bee yards are in harmony with nature and ecological environments made of materials like stone, wood and earth.

This study is the first time that the relief of the bee yards has been taken and transferred to a scientific area. There is no clear information about the measures of these formations in any of the studies done by Rudofsky, Günay and Tanal. As a result of our field research done in Söğle villages in the Elmalı district in Antalya, one bee yard in *Serkiz* Plateau, 2 in *Gölalanı* and 3 in *Çakşır Dibi* region are determined. It is seen that one of these bee yards is still standing with its complete formation intact and it is still used today.

In this study, one bee yard in Çakşır Dibi region is measured. The structure is formed without any bonding materials (mud, etc.) on a square body (212*212 cm) built with stone and wooden beams. A wooden platform (460*400 cm) is placed at a height of approximately 300 centimeters. On top of these platforms, beehives are formed by carving the turpentine tree trunks, which are placed on top of each other to form a comb texture, then bonded with mud and formed into a vault.

This is then covered with juniper barks and wood on top, and the structure is completed. Tree branches are placed on the stone body in the shape of a stair for the owner of the yard to reach the door at 170 cm to the wooden platform. One can get inside from this door (50*50 cm) and reach the upper platform (Fig. 1).

ANALYSIS OF THE ELMALI BEE YARDS (ELMALI ARI SERENLERI) ACCORDING TO BIOMIMICRY

ANALIZA PČELINJAKA U ELMALI (ELMALI ARI SERENLERI) PREMA BIOMIMIKRIJSKIM KRITERIJIMA

Honeycomb structures occur often in nature, as the hexagonal shape is the most densely packed structure in two-dimensional space. Technical honeycomb structures are made of plastic, ceramics, paper and metal. Honeycombs are used for the core of sandwich panels and composite designs. Due to their large surface area, they are suited for use in cooling machines and catalyzers. They are also used as surface layers for tires and packaging.[52]

A honeybee nest may contain around 10,000 adult insects that have constructed hexagonal cells made of wax for the storage of honey and for the rearing of their maggot-like larval stages. This is an extraordinary development of social living that has no equal among vertebrate animals other than among mankind.

45 *** 2011
46 *** 2011
47 WALKER, 2011
48 GÜNAY, 2008
49 RUDOFSKY, 1979
50 ISIK, ISKAN YILMAZ, 1996
51 TANAL, 2009; YAVUZ, 2009
52 GRUBER, 2011

Table 1. The analysis of bee yards according to Zari's biomimicry measures established in 2007.
Tablica 1. Analiza pčelinjaka prema biomimikrijskim mjerenjima koje je 2007. ustanovio M. P. Zari

Organism Level	**Form**	The building doesn't look like a honeybee.	
	Material	The building isn't made from the same material as a honeybee.	
	Construction	The building isn't made in the same way as a honeybee.	
	Process	The building doesn't work in the same way as an individual honeybee.	
	Function	The building does not function like a honeybee in a larger context.	Restitution of Bee Yards
Behavior Level	**Form**	The building looks like it was made by a honeybee; a replica of a honeycomb for example.	
	Material	The building isn't made from the same materials as a honeycomb.	
	Construction	The building isn't made in the same way that a honeybee would build it.	
	Process	The building doesn't work in the same way as a honeycomb would.	
	Function	The building functions in the same way that it would if it were made by honeybees; for example, internal conditions are regulated to be optimal and thermally stable. It may function in the same way that a honeycomb does, although in a larger context.	Restitution of Bee Yards
Ecosystem Level	**Form**	The building looks like an ecosystem (one that a honeybee would live in). (Mimicry of an ecosystem.)	
	Material	The building is made from the same kind of materials that a honeybee ecosystem is made of; it uses naturally occurring common materials.	
	Construction	The building is assembled in the same way as a honeybee ecosystem.	
	Process	The building works in the same way as a honeybee ecosystem.	
	Function	The building is able to function in the same way that a (honeybee) ecosystem would and forms part of a complex system by utilizing the relationships between processes.	Restitution of Bee Yards

In some aspects of their building, social insects even surpass humans; for example, in the scale of their structures.[53] Incidentally, honeybees use their bodies to create the wax cylinders around them that will form the cells of the honeycomb. But, you may be protesting, surely honeybees make those wonderfully perfect hexagons as an example of their masterful construction skills. Well, it seems that this is not the case. What the bees do is form a cluster on the comb, inside of which some bees start to build cylinders.

At the same time the cluster heats itself up by the 'shivering' of their collective flight muscles. The semi-molten wax cylinders then just flow together and, like the clusters of soap bubbles in your bath, create a beautiful geometry.

The building of hexagonal comb cells by wasps out of paper pulp does not involve any molten magic; however, it does require more control in the construction process, although we have little information on how.[54] The cells of a honeybee comb are, famously, hexagonal. This is a way of dividing up a plane surface into regular repeated units, without having gaps between them. There are two other

53 Hansel, 2007
54 Hansel, 2007
55 Hansel, 2007
56 Hansel, 2007
57 Hansel, 2005
58 Hansel, 2005
59 Zari, 2007

ways of doing this: squares (of course) and triangles, but where a triangle, square and hexagon are drawn to enclose the same area, the circumference is smallest for the hexagon. Therefore the wall of a hexagonal cell uses less wax than the wall of a triangular or a square section with the same volume. Therefore, hexagonal cells are more economical in the use of materials and of course are a better shape than either square or triangular cells for the plump bee larvae that grow inside and eventually fill them.[55] In 1985, a remarkable molecule of pure carbon was discovered, composed of sixty carbon atoms linked together. It proved to be a spherical molecule made up of sixteen identical hexagons and twelve identical pentagons, forming a skeleton reminiscent of the geodesic dome architecture of Buckminster Fuller.[56] The comb-building material of honeybees (Apis mellifera) can more strictly be referred to as wax.[57] Materials collected from the environment may be applied to the building without modification, or they may be processed in some way to make them suitable for building.[58]

Through an examination of existing biomimetic technologies it is apparent that there are three levels of mimicry; the organism, behavior and ecosystem. The organism level refers to a specific organism, like a plant or an animal, and may involve mimicking the organism in part or in whole.

The second level refers to mimicking behavior, and may include translating an aspect of how an organism behaves or how it relates to a larger context. The third level is the mimicking of whole ecosystems and the common principles that allow them to successfully function.

Within each of these levels, a further five possible dimensions of mimicry exist. The design may be biomimetic, for example, in terms of what it looks like (form), what it is made out of (material), how it is made (construction), how it works (process) or what it is able to do (function).[59] The analysis of the bee yards according to these measures is shown in *Table I*.

When the bee yards are studied according to Zari's biomimicry measures, it is seen that there is no relationship at the organism level; at the behavior level, the upper structure of the yard composing the vault cover formed by the carved turpentine tree trunks that are combined with mud is morphologically similar to the honeycomb formation. At the ecosystem level it is seen that the tree hollows used by honey bees before and after domestication are exactly the same as those used in this structure.

This relationship is improved in a way including form, material, construction, process and function level.

Conclusion

Zaključak

Although as Gruber indicated, vernacular architecture forms a source for biomimicry, important findings are reached in this study showing that there are formations built according to biomimicry rules in local architectural formations exposed as a result of local accumulations in the natural environment. Within the framework of both the bee yards' unique identity and Zari's biomimicry measures, it is seen that the bee yards are formed as being formal at the behavior level and in a way includes form, material, construction, process and function at the ecosystem level. In this study, along with the analyses done at the architectural measures level, the biomimicry relations of these structures can be more clearly exposed with studies of other science branches (e.g., biology, zoology, etc.).

[Translated by: Fatih Akdeniz, MA]

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Sources

Izvori

Illustration Sources

Izvori ilustracija

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Summary

Sažetak

Tradicijska graditeljska forma pčelinjaka u pokrajini Antaliji u Turskoj

Poljoprivreda je najvažniji element u izgradnji ljudskih naselja i razvoju civilizacije. Razvoj ljudskih naselja i civilizacije odvijao se paralelno s razvojem poljoprivrede. Proces uzgoja obuhvaćao je i biljne i životinjske vrste. U pretpoljoprivrednim društvima biljne su se vrste skupljale iz prirode i selekcijom su odabirane one koje su bile pogodne za uzgajanje. Opisani proces još se i danas koristi u poljoprivredi. Sličan pristup primjenjivao se i na životinjama. Primjerice, one životinjske vrste koje su se čovjeku pokazale korisnima bile su odabirane za pripitomljavanje i uzgoj. U tom smislu, izgradnja zakloništa za životinje kako bi ih se zaštitilo od vremenskih nepogoda, bila je osnovni preduvjet sjedilačkog načina života. Sva zakloništa za životinje građena su prema nekim lokalnim karakteristikama i ekološkim uvjetima okoliša. Ljudi su naučili skupljati med iz prirodnih skloništa pčela u vrijeme kada one same zadovoljavaju svoje potrebe za hranom skupljanjem iz prirode. Ljudi su se počeli baviti apikulturom (uzgojem pčela) tako da su skupljali med, ali nisu ubijali pčele koje su živjele u šupljinama stabala, te bi ostavljali nešto meda u pčelinjim boravištima. Iskapanja u Bogazkoyu u Anatoliji pokazala su da je apikultura bila važna poljoprivredna aktivnost u doba hititske civilizacije 1300. god. pr. Kr. Osim toga, med koji su proizvodile pčele u ono je doba imao i religioznu vrijednost pa se smatrao svetinjom. Med je imao simboličko značenje u mnogim društvima i svoje mjesto u svetim knjigama, kao što su Biblija ili Kuran. Zna se da su Turci koristili med i proizvode od meda kao lijek i kao hranu s ljekovitim svojstvima tijekom nomadskog načina života. Prema Mahmudu iz Kashgara, Turci su u početku med nazivali „medno ulje", a zatim su ga, osobito zapadni Turci (narodi Oguz, Kipčaki i Suvari), nazvali „med". Uyguri su ga zvali „mir". Također, zna se da je apikultura postojala i za osmanske vladavine. Zakloništa za pčele gradila su se, prije svega, kako bi ih se zaštitilo od prirodnih nepogoda i drugih životinja (primjerice medvjeda itd.). „Ari Serenleri" (pčelinjaci) imaju jedinstvenu formu kao arhitektonski element u ekološkom sustavu na visoravni Sögle u okrugu Elmali, u turskoj provinciji Antaliji. Takve izgrađene formacije nisu rijetkost u toj regiji koja je oduvijek bila jedan od važnih centara za proizvodnju meda. Ovo su jedini primjerci spomenutih arhitektonskih struktura u Anatoliji. U brojnim se istraživanjima ističe da pčelinjaci u arhitektonskom smislu potječu još iz antičkih vremena, iako te tvrdnje, utemeljene samo u formalnoj sličnosti, nisu zadovoljavajuće. Ari Serenleri (pčelinjaci): U nekim područjima oko visoravni Sögle postoje skupine crnih košnica na platformi postavljenoj na toranj. Takva formacija naziva se pčelinjak. Tijelo pčelinjaka izgrađeno je tehnikom suhozida s gusto postavljenim gredama, visine između 5 i 10 metara. Platforma na vrhu te konstrukcije sastavljena je od drvenih greda, isturena na četiri strane u obliku strehe. Crne košnice na tim platformama formirane su izrezivanjem unutrašnje strane debla drveta i postavljane jedna iznad druge u obliku trokuta. Šuplja debla, pokrivena drvenom šindrom i korom drveta, predstavljaju zaštitu za pčele. Konstrukcija je formirana bez ikakva vezivnog materijala (blata i sl.) na kvadratičnom tijelu (212x212 cm) izgrađenom od kamenih i drvenih greda. Drvena platforma (460x400 cm) postavljena je na visinu od otprilike 300 cm. Na vrhu tih platformi nalaze se košnice postavljene jedna iznad druge u obliku pčelinjih saća, a povezane su blatom. Ta se konstrukcija pokriva korom drveta i time je završena. Grane drveta postavljene su na kameno tijelo u obliku stuba kako bi vlasnik pčelinjaka mogao dosegnuti vrata na drvenoj platformi na visini od 170 cm. Unutra se može ući kroz vrata (50x50 cm) i doći do gornje platforme. Svaka je ljudska zajednica, inspirirana prirodom, stvorila svoju jedinstvenu arhitektonsku formaciju. U tome smislu smatra se da heksagonalna struktura saća koju formiraju pčele može nastati na gornjoj razini pčelinjaka te da se pčelinji ekosustav nastavlja na prirodan način. U ovoj studiji primjerci pčelinjaka analizirani su prema mimikrijskim mjerama koje je utvrdio Zari (2007.). Rezultati analize pokazuju da nema elemenata mimikrije na razini organizma: mimikrijski element povezan je s gornjom konstrukcijom pčelinjaka samo u smislu forme na bihevioralnoj razini i povezan je s formom, materijalom, konstrukcijom, procesom i funkcijom na razini ekosustava. Ove tvrdnje proizlaze iz opažanja. Moguće je dobiti različite podatke ako se rezultati ovoga istraživanja prouče u sklopu drugih znanstvenih područja. K tome očito je da su ove formacije nastale na tradicijski način dugotrajnim promatranjem ekosustava. Vidljivo je da su pčelinjaci građeni u regijama bogatima biljnim vrstama (3000 vrsta), gdje se održava prirodni životni okoliš pčela (šupljina drveta – deblo). Iako, kako navodi Gruber, tradicijska arhitektura predstavlja izvor biomimikrije, rezultati ovoga istraživanja pokazuju da postoje formacije izgrađene prema biomimikrijskim pravilima u lokalnim graditeljskim formama. U sklopu jedinstvenoga identiteta pčelinjaka i biomimikrijskih mjerenja Zarija vidljivo je da su pčelinjaci građeni u formalnom smislu na bihevioralnoj razini, uključujući formu, materijal, konstrukciju, proces i funkciju na razini ekosustava. Ova studija upućuje da se, uz analize na razini arhitektonskih mjerenja, biomimikrijske veze ovih struktura mogu nadopuniti istraživanjima u drugim granama znanosti (biologija, zoologija itd.).

Mehmet uysal
Yavuz arat

Biographies

Biografije

Mehmet Uysal (1973) is an architect. He earned his BA degree at Selcuk University. He earned his MA and PhD degree at the Institute of Natural and Applied Sciences at Selcuk University. His master's thesis was about traditional dwellings and his doctoral thesis on spatial and morphological analysis of commercial buildings. His research areas include culture and space, biomimicry, vernacular architecture and architectural education. He works at Selcuk University.

Yavuz Arat (1980) is an architect. He earned his BA degree at Dokuz Eylül Üniversity. He earned his MA and PhD degree at the Institute of Natural and Applied Sciences at Selcuk University. His master's thesis was titled Houses for the Elderly and his doctortal thesis was Antropometry, Interior Space Components and the Traditional Turkish House. His research areas include biomimicry, vernacular architecture and ecological design. He works at Selcuk University.

Mehmet Uysal (1973.), arhitekt. Diplomu prvostupnika arhitekture dobio je na Sveučilištu u Selcuku. Magistrirao je i doktorirao na Institutu prirodnih i primijenjenih znanosti na istom sveučilištu. Njegov magistarski rad bavi se tradicijskim boravištima, dok je tema njegova doktorskog rada prostorna i morfološka analiza poslovnih zgrada. Područja njegovih istraživanja su kultura i prostor, biomimikrija, tradicijska arhitektura i arhitektonsko obrazovanje. Zaposlen je na Sveučilištu u Selcuku.

Yavuz Arat (1980.), arhitekt. Diplomu prvostupnika arhitekture stekao je na Sveučilištu Dokuz Eylül. Magistrirao je i doktorirao na istom sveučilištu. Tema njegova magistarskoga rada nosi naslov Stanovanje za starije osobe, a tema doktorskoga rada Antropometrija, Elementi interijera i Tradicijska turska kuća. Područja njegovih istraživanja jesu biomimikrija, tradicijska arhitektura i ekološko projektiranje. Zaposlen je na Sveučilištu u Selcuku.