Characteristics of Reptiles as a Model for Bionic Architecture

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Abstract

Bionic as trustable solutions which provided by nature can be useful in different field of sciences. Living creature used different strategies to live in harsh climate. In vertebrates, reptiles have some special features that make them significant in getting adaptability to environment. At first look mammalians are the most evolved creature in the world which can tolerate different situations, but the way that they using need consuming a lot of energy to keep the temperature of their bodies constant. Reptile as the most developed coldblooded animal use different solutions to live in harsh climate. In fact, they minimize the rate of energy consumption by different solution .This article tries to show some of these features which have capability to use in bionic architecture. Ultimately, this article concentrates on the solutions which they use to cover the lack of thermoregulation system and then expand these solutions in architecture.

Keywords: Reptiles, Bionic Architecture, Adaptability, Ventilation, Pattern

1. Introduction

The relation between nature and human considers different periods. at first it was bio-utilization which degrade the value of nature as a source of energy and material. After revolution in science development and attention to the damages which they made to environment, they tried to change their look to this issue and expand the mean of relation between human and nature. Birth of such word like biognition emphasize on the new point of view at nature.
These days using biological pattern expands in different field of science. This paper by concentrating on reptiles of arid climate tries to introduce some solutions which are useful to adapt to the environment and offer to use them in designing process. Special features in morphology and anatomy of these creatures shaped in order to get more compatibility with environment (Costa, 1995). Expansion of solution to the architecture appears its result as sustainability and gives us some trustable solutions which examined in nature during different periods. Reptiles use suitable strategies to live in arid climate, despite lack of thermoregulation. Their solution based on reducing energy consumption which can use in bionic architecture as a pattern.

According to the researches the amount of energy which reptile use in comparison with mammalians is 10% less and this fact gives them the ability to live in such harsh condition. On the other hand the skin of reptiles are comparable with the external wall of buildings, as the skin has controlling role in temperature and humidity of the body, the windows on the wall of buildings are responsible for ventilation. So using smart windows can reduce the amount of energy consumption.

2. Desert and its fauna

The fauna of each area obeys the climate features, desert as a division of arid climate has some characteristics which make it harsh condition to live. A region that receives less than 10 inches of annual precipitation is the most-used definition. Nevertheless, low precipitation is not the only criterion. Areas with precipitation rates higher than 15 inches are defined as deserts if there are high rates of evaporation. The large difference between the temperature of day and night, also the deficiency of water are the main signs of desert (Gibson, 1996). According to these facts human intervention can
make it harder if they don’t pay attention to their influences on the desert ecosystem. Figure 1 shows the exchange of heat for lizard in an ecosystem. One of the most trustable ways to use in designing buildings refers to natural patterns which nature gives us.

3. **Bionic Architecture**

Bionic architecture by making relation between biological structures and architecture tries to introduce a new sort of sustainable architecture. Nature by different exams approved its capabilities to use as a model to copy in different aspects. The use of bionic architecture has defined in different viewpoints and it forms different approaches, but the three main viewpoints which accepted these days consist of three main ideas which can obtain from biological structures, behavior of creatures and the relations in ecosystem (Janine, 1998). Each of these viewpoints can expand from different approaches such as: formal, functional, material, process and structure (Fig 2).

![Figure 2. Different approaches based in three viewpoints](image)

Study of reptile in arid climate and attention to the way of adaptation to the environment such as other field of bionic can expand in different viewpoints, this article concentrate on biological structure and the behavior of reptile which related to temperature in arid climate. Special characteristic of reptiles make them different from other group of animal which live in this climate and emphasize on the way of energy consumption give them more value to be a pattern for architects (Yagil, 1958).

4. **Features which make reptiles compatible with arid climate**
4.1. Skin of reptiles
The epidermis of reptiles totally covered by keratin, the skin of reptiles have vital role in regulation of water evaporation from the skin, at the first look it seems totally dry but it can lose a lot of water, and act as an insulator for water evaporation (Peck, 1990). These part of reptiles can expand to the external wall of building which has different opening part to regulate ventilation in the buildings, using smart windows which measures the temperature inside and outside of building and regulate the rate of opening can be useful for saving energy in achieving comfort condition (Carlson, 2002). On the other hand skin of some reptiles can absorb water by using the humidity of air.

4.2. Suspended animation

The temperature drop in cold season reduce the activity of reptile and finally cause hibernation, on the other hand when the temperature rises it cause another kind of problem for them because they do not have any temperature regulator system like mammalians or birds. Aestivation is their solution for tolerating high temperature in summer. Both hibernation and aestivation call suspended animation which introduce a solution of reptile in harshness of climate and they just reduce their activity in this condition in spite of consume a lot of energy to tolerate it. On figure 3 temperature fluctuations showed in different depth of soil in Namib Desert. So the ground can provide a shelter for reptile in both summer and winter.

But how does it work in architecture?! In ancient Iranian architecture central yard consist of spaces which arranged in different directions. Northern porch and southern one use in different seasons and the function of them obeys the sunlight direction which is the source of energy for buildings, by other words different parts of traditional building have suspended animation (Tsui, 1999).

4.3. Excretion and respiratory system

Reptile in comparison with other animals can continue to their life more easily. Their excretion system adapted in a way to excrete ammonia as crystalline solid sulfuric acid and by this solution they save a lot of water. On the other hand the skin of reptile can quit the evaporation of water from the skin and as a result of this process animals can obtain all water requirements from their foods. The value of water in building designing in arid climate show in different way, most of solution based on using water in central part or cover area of building to keep the humidity inside the building and prevent evaporating. In central yard pool surrounded by trees or under the wind tower they installed a small
pool to increase the humidity of airflow (Macy, 2003). Also the water in reptile keep in internal part more than external layer, for instance comparison between the water inside outer layer of skin and inside body show this fact.

Figure 3. Temperatures below the sand surface, measured at 4-hourly intervals on a dune surface in the Namib desert in the (a) winter and (b) summer

Respiratory system in reptiles which live in desert has an additional function. As the main function it absorbs oxygen and excretes carbon dioxide. On the other hand it act as heat absorber in the middle of the body and transit heat to the air in order to leave body. The respiratory system has adapted to act with a little humidity during the process of respiration.

4.4. Solar energy absorption

By comparison of reptile and mammals this fact obtained that a reptile just consume 10% of a food which a mammal use in same weight. The reason refers to the temperature regulating system. When mammals need a regulating system to fix their temperature in different conditions it is obvious that they have to consume a lot of energy for this purpose. But in reptiles another story is running, they try to get a major part of energy from the sun to make their body warm. Their ability to adapt with different condition gives them the ability to live in different climate. Architects also paid attention to solar energy in traditional buildings of Iran by using some kind of material which has high thermal capacity to save this energy in material during the day and use it at night when the temperature falls down (Turner, 2003).
4.5. Ability to change their diet

Reptile in nature usually has their special diet, some of them nourish from plant and others nourish from animals but the point related to their ability in changing diet which shows their flexibility in life, for instance a species of plant-eating lizard in status of captivity become carnivorous. Many of green sources of energy can work together more effective because the lack of a special sort can replace by other sources (Fathy, 1986). Using solar and wind energy to achieve comfort condition in traditional buildings of Iran is the main solution in sustainable architecture.

4.6. Increasing in length of hands and feet in some reptiles which are active during the day

In some reptile which lives in arid climate the length of hands and feet changed and became longer, this policy act as solution to reduce the surface of body which is in contact with hot ground. As a result one of the main points which can use in architecture refers to reduce the surface of building in order to decline the amount of energy which absorb at day or lost at the night (Cohen, 2005). In arid climate architecture decreasing the surface to volume ratio, is a common strategy.

4.7. Sheltering in the ground

A lot of reptiles shelter in the ground from harshness of climate that it is a part of aestivation process. This behavior used as a pattern in architecture, in ancient Iranian architecture buildings has special underground spaces which called Shavadoon (Gernot, 2009). These kinds of space usually use as a place for keeping food or resting place in the time which outside temperature is intolerable (Fig 4).

![Diagram of ventilation in shavadoon and shelter of lizard in desert](Zare, 2011)
4.8. Eating more food before hibernation

Reptile before hibernation eats a lot of food and makes a source of energy for themselves during this process. Same solution used by architects to keep the temperature inside building in better condition. In Iranian ancient architecture central yard by keeping trees and a pool, accepted this responsibility to save the solar energy during the day and give it back to consume during the night. This process cause decreases the different between temperature during the day and night inside buildings.

4.9. Metachromatism

Special feature in reptiles give them this ability to change their color based on the temperature of environment and the intensity of sunlight. They adjust the amount of energy which they want to absorb by this policy. Due to lack of thermoregulation system in reptile special behavior can help them to be in better condition. Also this solution can use in building to control the amount of energy which a building absorb in different conditions (Zari, 2007).

4.10. Thermoregulation

Thermoregulation is a system which used in mammalians and birds to keep the temperature inside their body in constant degree; it made them able to live in different climate but this method needs consuming a lot of energy. Figure 5 shows the amount of energy consumption in comparison with mammalians. For a place like central desert of Iran which the nutrition sources are limited, saving energy is vital. Reptiles reduce their energy consumption by lack of thermoregulation system, by other mean they are slave of environment temperature, but it is their power point to live in such harsh climate. They use different strategies to promote their ability in tolerating such conditions.

*Figure 5.* A comparison of mass and mitochondrial membrane surface area (MSA) of the liver, kidney, heart and brain of a mammal (R. norvegicus) and reptile (A. nucalis) of the same body mass. Data from Else and Hulbert (1981).
One of the solutions which use by this animal to adjust the sunlight absorption refers to their orientation toward sun. Whenever they need more energy they orient in a way to absorb more energy. The angle between surface of body and sun rays use as a parameter to change the rate of energy absorption. This is one of the strategy which architects use in first steps of designing process (Dalzell, 1986).

5. *Usable pattern of reptile in bionic architecture*

Parts of solution for getting sustainable architecture relate to structure and behavior of living creature. Reptile as a group of compatible fauna use different solutions to live. This article mentions some of them, for better imagination. Table 1 compares the solution which use in reptile and architecture and show the common purpose of both. Orientation of building, using compatible material with climate, reduce the surface of building in comparison with volume and saving solar energy in different part of building to use it at night all together shows solution to get sustainable architecture.

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6. *Emergence of biological means in architecture*

According to morphological and anatomical features of reptiles different sort of adaptability exist to give them ability to live in harshness climates. Based on bionic architecture all of these patterns can categorize in three main groups which consist of biological structures, behavior and various relation in ecosystem.

For instance the adaptability of epidermis to save water is one of the main changes which give ability to tolerate such dry condition, or absence of significant thermoregulation system reduce their
energy consumption into 10% present of mammals which is a point to live in arid climate. From morphological point of view, different changes emerge to reduce the surface of body to decline the amount of energy transition. In other viewpoints these answers appears in behavior of reptiles which define their active period of life. Most of these creatures through the suitable behavior get the chance of life in such harsh climate. Merging of biological structure, behavior and complicated relation in ecosystem make them able to live in desert.

Figure 6 shows the relation between natures that consists of living creatures with architecture. All features of reptiles which mentioned before can summarize by this diagram. This model gives the chance to look at the animal solutions in arid climate from different points of views. In fact this model shows the strategy of architects in four sections which consist of ventilation, humidity, source of energy and thermoregulation and tries to make connection with animal solutions by the path of bionic science. Also it facilitates the process of getting pattern from nature and using it in architecture. Figure 7 showed different layer of insulated wall. These kinds of walls of the houses have two or three times the standard levels of insulation. To achieve this purpose two separate stud wall constructed with insulation in the outer stud wall, between the two walls and also in the inner stud wall (Vale, 1991).

Designing insulated wall is a common solution in architecture which obeys different criteria of climate condition. For instance in cold climate there is no need to pay attention to ventilation as arid climate. Based on features of reptiles and characteristic of arid climate this article suggests a new sort of smart wall in the next section.
7. Ventilation and radiator curtain as the concepts of designing smart wall

According to the life style of reptiles one of the main solutions for tolerating harsh condition is sinking into the ground, on the other hand using underground spaces was a solution which used in building designing.

Figure 6. Diagram of double stud construction a vapour barrier; b inner stud wall with insulation; c cavity filled with insulation; d outer stud wall (Vale, 1991)

Figure 6. Relation between architecture and living creatures in desert
This strategy offers a new sort of wall which acts as an insulator for buildings. To achieve this purpose, fresh air collected by wind towers goes above the water in the pit and loses its temperature. The result is cool fresh air, which is stored in the underground space. Whenever the temperature of air between the facade and the main wall (a high thermal capacity wall) reaches 32°C, the hatches on the top and bottom of the wall will open, allowing air flow to reduce the temperature of this space. In the next step, if the temperature goes up more than 40°C, the spatters will spray water on the blade installed in the middle space. These two compatible solutions can act as an insulator for the main wall and, on the other hand, do not need lots of energy to function. Another pattern, which is capable of use in architecture, relates to the use of radiator curtains. Some lizards use their ears as the radiator of heat into the environment, or others have a curtain of skin around their neck to act as a radiator and cool down their body (Fig. 8). This article suggests using these kinds of solutions as radiators. These sorts of external curtains act as heat radiators in buildings and transit the heat of buildings to outside spaces.

8. Conclusion

In architecture to reduce heat transitions, different solutions are used by concentrating on reptile behavior.

To decrease the amount of thermal transitions between buildings and the environment, architects decline the surface to volume ratio.

Another solution appears in Iranian architecture by creating some special sort of underground spaces which are called Shavadoon.
Color as a factor in absorbing solar energy use by reptile which modeled by architects in buildings by designing smart facade.

As a final result a new sort of smart wall designed which use the coolness of underground space and the force of wind as two main factors in function. Attention to the exterior layer of skin in reptile leads this project to design a layer around the building with the special features.

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