International Journal of Fauna and Biological Studies
Available online at www.faunajournal.com

International Journal of Fauna And Biological Studies

ISSN 2347-2677
IJFBS 2018; 5(4): 74-79
Received: 12-05-2018
Accepted: 13-06-2018

İnanç Özgen
Fırat University, Engineering Faculty, Bioengineering Department, Elazığ, Turkey

Correspondence
İnanç Özgen
Fırat University, Engineering Faculty, Bioengineering Department, Elazığ, Turkey

Utilization from insects in biomimetics

İnanç Özgen

Abstract
There are "awe-inspiring" systems in the nature. Effective observation of these systems and their adoption in life are highly important. Insects are the most interesting creatures of the animal kingdom. Their life events, behaviours, physiologies, morphologies should be investigated in detail and adopted in life. In bio-material production processes - especially in defence, space and mechatronics applications- modelling of nature and particularly insects will break new grounds in technology. Studies to be conducted in this field will lead to a breakthrough in designs of materials such as new solar cells, space tools and equipment, self-regenerating cells and under-water equipment.

Keywords: Biomimetic, insects

1. Introduction
Biomimetics is the creation of systems, processes and structures through the imitation of nature by humans. The science and art of designing biomimetic parts is known as bio-mimicry. The areas of special interest for researchers carrying out studies in this area include the nanotechnology, robotics, artificial intelligence, medical industry and military areas. Biomimetic designs have … within years. In the recent years, biomimetics are being suggested for practices in the design of visual systems of machines, sensational systems of machines, signal verifiers, navigation systems and data transformers (Anonymous 2016) [1]. Animals have undergone evolution for millions of years to a level that they will have more capable of surviving in their environment. Animals have developed to adapt to extremely harsh environments with significantly diversified superficial structures on their bodies. Studies on structures of animals, general features used in biomimetics, and very general superficial characteristics including those used for reduction of noise, protection from abrasion, absorption of water and optic surfaces have increased. Later, some typical morphological features, structures and particularly skin structures of animal have been considered and mimicked in the designs of various surfaces.

In the recent years, mechatronic engineering uses systems resembling biological systems particularly in structures and systems of robots when designing robots in its biomimetic applications. Legs of insects have an important place among these structures. Neurologists are also using biological basics of animal movements when designing robots.

Biologists are transferring the knowledge they have achieved in relation with animal movements to engineers to provide them with the possibility of using this knowledge in hardware and software. Scientists are adding to technological advancements by designing antimicrobial fabrics without chemical processes inspired from shark skin to be used in swimming suits for Olympic swimming races with features making horizontal and vertical movements easier (Figure 1) (Han ve ark. 2016) [8]. Since swimmers now wear swimming suits designed based on the hydrodynamic principles of the shark skin, such important sporting activities are now leading the way in technological support. Such tightly-fitting cloths are prepared from fabrics designed to imitate the shark skin by placing resin bands vertically one over another (Figure 1) (Han *et al*., 2016) [8].

In parallel with these developments, new turns have been yet taken through the mimicry of insects, which have species with the greatest number in nature.

The general perspective of biomimetics and use of insects as models have been summarized in this review together with the latest technological advancements.

Fig 1: Bathing suit designed by modeling the surface of the shark skin (Han *et al*., 2016) [8].

2. Biomimetics Applications on Insects

Application areas related to biomimetics are diverse. For example, researchers have made use of *Periplaneta americana* Linnaeus (Orthoptera: Blattidae), which is an American cockroach species when designing a robot with 6 legs. The great speed and agility of this insect, and also the well understanding of its structure have ensured important clues for the design of the robot. When designing the bodies and legs of robots, equivalent structural size of cockroach was designed with a magnification of 12 to 17 folds. When designing the robotic legs, each leg was designed as coxa, femur and tibia like in the legs of this insect. Designing the structures so as to resemble those in insects has provided for flexibility and adaptation for the movements of the robot (Delcomyna and Nelson 2000) [5] (Figure 2, 3).

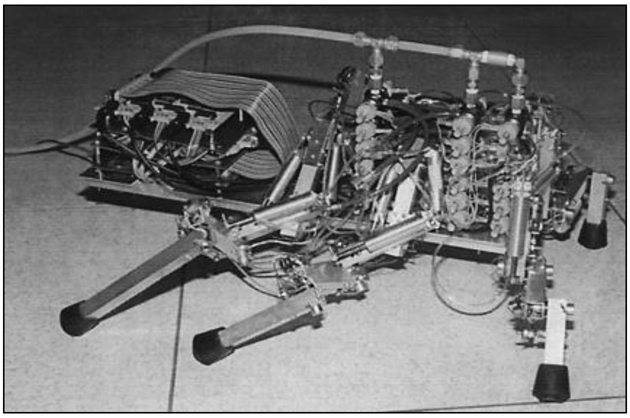


Fig 2: A biomimetic robot designed to mimic the American cockroach Periplaneta Americana (Delcomyna and Nelson 2000) [5].

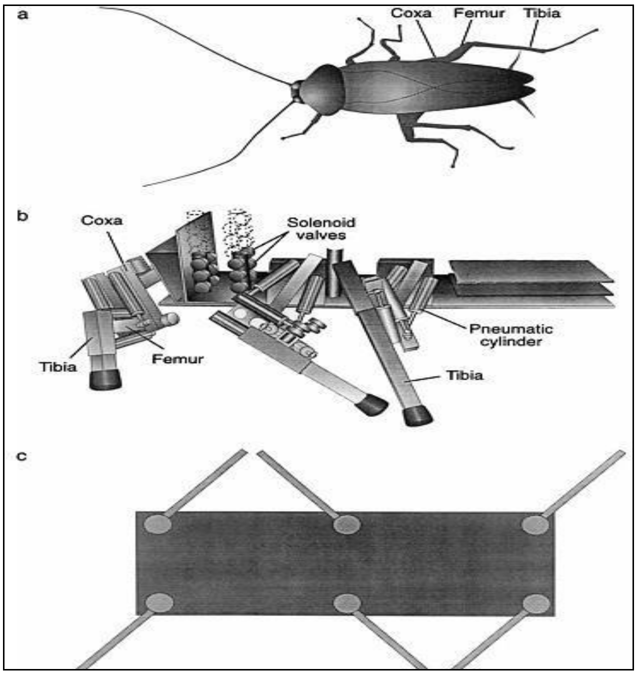


Fig 3: (a) Positions of legs of cockroach when it walks (b, c) similar designs (Delcomyna and Nelson 2000) [5].

The land vehicle with 6 legs designed based on the structure of cockroach legs is shown in Figure 4 (Anonymous, 2011) [2].

Fig 4: The six-legged land vehicle (Anonymous, 2011) [2].

In addition, the wing control mechanism in some diptera (two-wing insects, flies) during flight has been examined and used for comparison when determining the flight control capabilities of pilots during flight. Aerodynamic characteristics of Drosophila melanogaster Meigen, 1830 (vinegar fly) have been studies with this purpose.
Formation of surfaces with structures resembling that of butterfly wings have been commenced making use of the effectiveness of the hydrophilic nature of the butterfly wings. Structure of feet of species of the Gerridae (water-runners) family has been examined to in relation with their ability to walk on water, and the hydrophobic structures of the hair on their feet has been used as a model. These have been taken in use in the manufacturing of some fabrics, carpets and some other nano materials (Şekil 5).

Fig 5: Individuals of Gerridae walking on water.

In some other studies carried out in the recent years, Nguyen *et al*. (2010) [11] studied data obtained from the observation of free flights of beetles, and found that a motor flapper could be designed using the mimicry of wing dimensions, frequency of wing flapping and kinematics of the wings and designed micro air vehicles based on these modeling. In these air vehicles, turning mechanisms in wings, aerodynamic characteristics, control mechanism for the flyişng balance and maneuvering capabilities in horizontal and vertical flight have been considered. Such researches will provide important experience in relation with the development of Flapping Wing Micro Air Vehicle (FWMAV) through the imitation of beetles. (Figure 6) (Nguyen *et al*., 2010) [11].

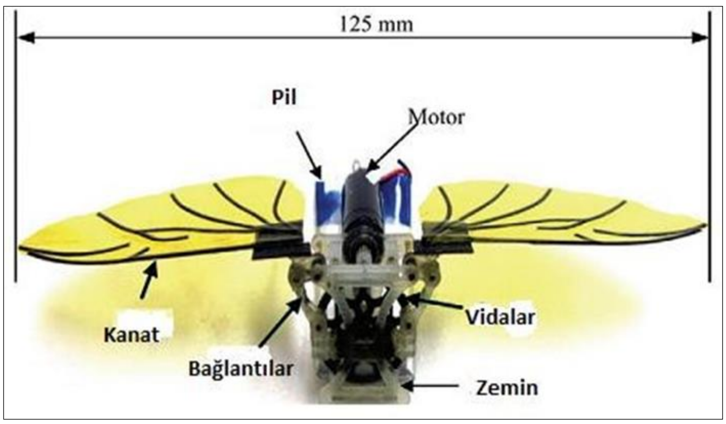
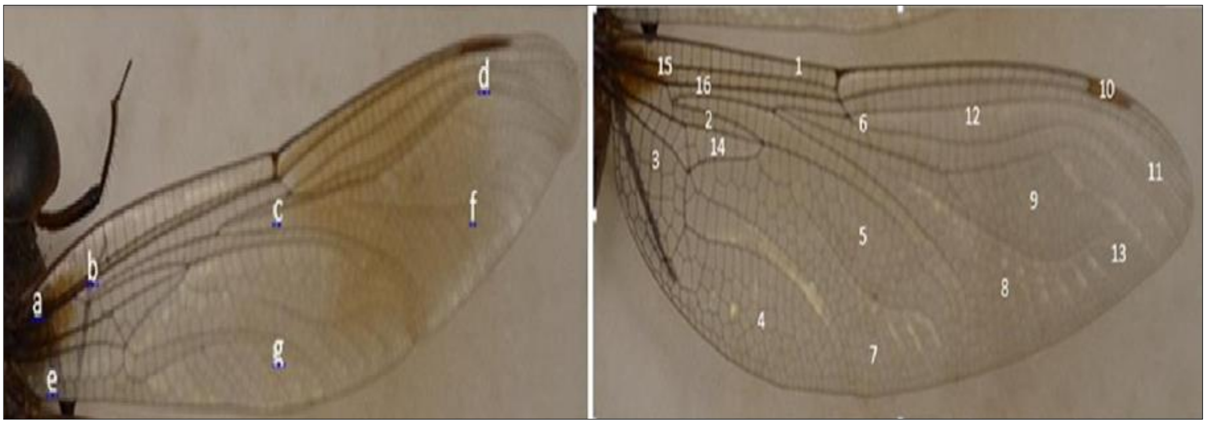


Fig 6: A small air vehicle designed based on an insect model (Nguyen *et al*., 2010) [11].

Again with the same purpose, membranous structure of the wings of Odonata (dragonfly family) has been modeled to design wings (Figure 7). Their magnificent flying capabilities are probably related with their complex wing structure. In general, wings of flying insects contributes to the total body weight by only 1% to 2%. These lightweight wings allow the insect to flap its wings millions of times throughout its life despite persistent impacts, twisting loads and many other forms of deformation. Bio-imitation of these characteristics in airplanes is something desired (Nguyen *et al*., 2010) [11].



(A) (B)

Fig 7: (A) Main parts for the wing of a dragonfly: (a) forearm vessel; (b) the hardest one of all the parts, costa – the leading edge; (c) nodus (the part of the vessel, which plays a very important role in the distribution and storage of mechanical energy and much thicker than others); (d) pterostigma (acts like a dampener); (e) anal edge and supercosta; (f) small hexagonal shaped tissues arranged in sizes ranging between 0.0001 and 0.0002 m; (g) larger rectangular and hexagonal tissues arranged in sizes ranging between 0.0002 and 0.0004 m, (B) The wing is divided into branches (The numbered areas highlight the areas that must be taken into consideration when creating a simplified structure) (Nguyen *et al*., 2010) [11].

In their study, Nyugen *et al*. (2010) [11] created a detailed model on the digital images of the head and back wings of the dragonfly using Canny edge detection method, and then developed simplified models from the detailed model using the spatial mesh analysis method. Natural frequency and corresponding modal forms have been examined using modal analysis criteria (MAC) and Autodesk to calculate the static bending and twisting binding results. It has been shown that very similar results have been obtained with simplified models (3 to 10% difference for all calculations). These results show that spatial analysis method is a suitable approach to simplify a complex insect wing – such as that of a dragonfly. It appears possible to produce a simplified model for the manufacturing of micro laser cutting machine (Sivasankaran and Ward, 2016) [12].

Various airplane models are being created by taking the flight abilities of dragonfly (Sun and Bhushan, 2012) [13]. Structure, durability and flexibility of wing vessels have been examined together with their existence in the wings. Effects of the Nodus in the wing on strength and flexibility have been examined as an example. Since the presence of vessels vary in species, further studies are required in this area. The superior capabilities in wing maneuvers of dragonflies will be helpful in modeling lightweight air vessels. Colors and color designs of insects are also among the subjects of interest for biomimetics. Colors are important in the sales of products. Color is an important factor for better sales of a product. Many colors are disappear and deteriorate in nature very quickly. In particular, metallic colors of some beetles are being used in many products. Nano structures within the insect cuticles are being examined. These colors on the wings of beetles include superficial lines, micro lenses and photonic crystals. Studies are being performed on such structures about the reflection of light together with other morphologic studies to use the compositions of these colors in artificial color designs on diverse materials (Lenau and Barfued, 2008) [9] (Figure 8).

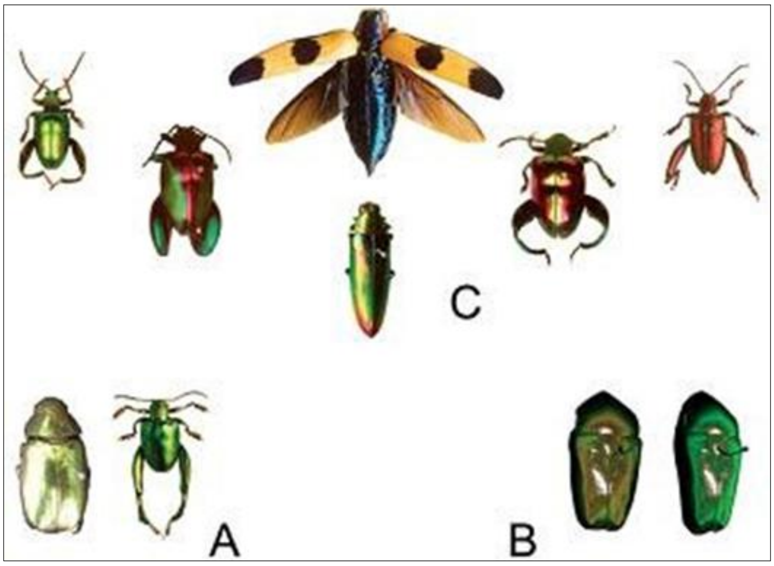


Fig 8: Beetles with Metallic Colors (Lenau and Barfued, 2008) [9].

Excavation and root-cutting abilities of *Cryptotympana atrata* (Fabricius, 1775) (Hemiptera: Cicadidae), which is a species belonging to Cicada, have been examined and its claws have been taken as a model (Figure 9). A biomimetic cutting machine for stubble has been invented through the modeling of these capabilities. Two types of biomimetic stubble cutters with different tooth heights have been designed (5mm and 2.5mm). Performance of the grass mower has been improved with the help of this invention made with reverse engineering (imitation of the existing) (Chang *et al*., 2016) [3].

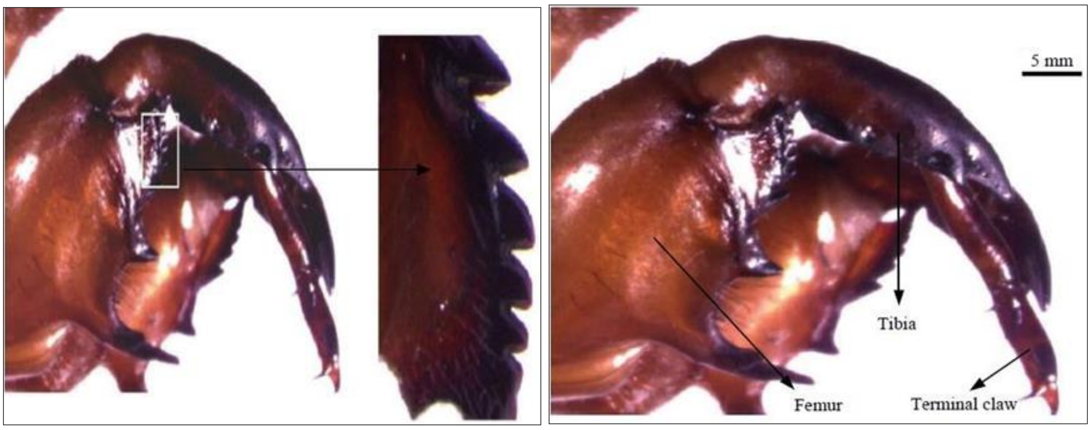


Fig 9: Claws and the ragged structure in Cryptotympana atrata (Fabricius, 1775) nymph (Chang *et al*. 2016) [3].

In a study on *Dorcus titanus* Boisduval, 1835 (Coleoptera: Lucanidae), epi-, exo- and endocuticular structures of the cuticle have been examined, and lamination of the natural sandwich structure have been studied in detail. A bio-composite containing a layer of chitin and fiber and a matrix of solid protein have been determined as the construction materials of the sandwich structure. This system is suitable for use in fiber foot panel structures (Chen *et al*., 2015) [4] (Figure 10).

Fig 10: Sandwich lamination of the cuticle and fiber panel foot structure (Chen *et al*., 2015) [4].

3. Conclusion

In conclusion, biomimetics and its applications that adapt the basic dynamic of the nature to technology is a promising area with an open end. Studies through the mimicry of not only on insects but also other invertebrates and their physical and morphological dynamics are gaining speed. Shells of marine species, aerodynamic flight capabilities of bats, maneuvering capabilities of alligators and scope of these capabilities, imitation of spiders' web and mimicry of their hopping capabilities (Li *et al*., 2012) [10] and their use in the creation of integrated hopping robot prototype can be given as examples. Grasshoppers find their way during their migration with the help of electronic signals without colliding with each other and move around without collision. This issue will also act as a model for the safe moves of land and air vehicles. Land and air defense industries will also achieve significant gains from the imitation of living beings of the nature. The very silent flight of birds like owls has been one of the models that had attracted the attention of scientists. Several countries are making progress in this area using the molecular technology. Nanobiotechnology is among the areas that should be taken into consideration together with biomimetic studies for the creation of important and useful products. Space technology and researches must also be considered together with biomimetic studies, and more detailed analysis of nature must be aimed at.

4. References

1. Anonymous. Biomimetiks, 2016. http://whatis.techtarget.com/definition/biomimetics. Alıntılama (Erişim tarihi: 16.08.2016).
2. Anonymous. The Biomimetic Six Legged All-Terrain Vehicle, 2011. http://northdesignlabs.com/?p=38.
3. Chang Z, Liu W, Tong J, Xie H, Yang X, Mu H *et al*. Design and Experiments of Biomimetic Stubble Cutter. Journal of Bionic Engineering. 2016; 13:335-343.
4. Chen B, Yin D, Ye Wei, Lin Shiyun, Fan Jinghong, Gou J. Fiber-continuous panel-pilar structure in insect cuticle and biomimetic research. Material and Design. 2015; 86:686-691.
5. Delcomyna FN, Nelson EM. Architectures for a biomimetic hexapod robot. Robotics and Autonomous Systems. 2000; 30:5-15.
6. Faruque I, Humbert JS. Dipteran insect flight dynamics. Part 1. Longitudinal motion about hover. Journal of Theoritical Biology. 2010; 264:538-552.
7. Guo Z, Liu W, Su BL. Superhydrophobic surfaces: From natural to biomimetic to fuctional. Journal of Colloid and Interface Science. 2011; 353:335-355.
8. Han Z, Mu Z, Yin W, Niu S, Zhang J, Ren L. Biomimetic multifunctional surfaces inspired from animals. Advances in Colloid and Interface Science. 2016; 234:27-50.

9. Lenau T, Barfoed M. Colours and Metallic Sheen in Beetle Sheels – A Biomimetic Search for Material Structuring Principles Causing Light Interference. 2008; 10(4):299-314.
10. Li F, Liu W, Fu X, Bonsignori G, Scarfogliero Stefanini C, Dario P. Jumping like an insect: Design and dynamic optimization of a jumping mini robot based on bio-mimetic inspiration. Mechatronics. 2012; 22:167-176.
11. Nguyen QV, Truong QT, Park HC, Goo NS, Douyong B. Measurement of Force Produced by an Insect Mimicking Flapping Wing System. Journal of Bionic Engineering. 2010; 7:94-102.
12. Sivasankaran PN, Ward T. Spatial network analysis to construct simplified wing structural models for Biomimetic Micro Air Vehicles, Aeorospace Science and Technology. 2016; 49:259-268.
13. Sun J, Bhushan B. The structure and mechanical properties of dragonfly wings and role on flyability. Comptes Rendus Mecanique. 2012; 340:3-17.