Evidence for Evolution

The Lizards from Pod Mrcaru

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>Biology/evolutionary theory/medicine

SCIENCE AND TECHNOLOGY EXPLAINED 2010

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Theories, Models, systematizations, these mental constructs that enable us to understand the ontology, the laws by which nature governs itself does not elude any scientific knowledge department, especially the vast universe of bio-entities which in their programmed, nihilistic, ruthless dance they offer a show that demands an explanation. Paradoxically, these complex phenomena of the universe we live in have the gift to be explained by theories that are much easier to understand than other theories explaining more simplistic phenomena; gravitational attraction, the curving of space-time, interactions between subatomic particles are some of this manifestations reflecting the structure of reality that unfortunately require extensive knowledge of mathematics, physics, etc., tools inaccessible to the average individual.

Charles Robert Darwin (February 12 1809 - April 19 1882), this Shakespeare of classical science, was the first who tried to explain the phenomena, diversity, complexity that biological entities are bathing in, from the unicellular organisms with elevated levels of immobility in the natural environment, to such versatile constructs as human organisms equipped with a sufficiently augmented number of degrees of freedom to reflect the stage of complexity they are located at.

To understand more clearly the power of explanation of biological phenomena by the theory of evolution by descent with modification written by Darwin along the more than 27 years of work, and of course augmented, modified, enhanced by the entire scientific community during the last 150 years since the publication of "The Origin of Species", we will experiment a counter intuitive approach; we will start to recount the examples, the evidence, the interesting parts from the imaginary point of view, and we will gradually arrive at a minimal set of definitions that will show us the system of rules by which nature, biological systems self govern themselves.

The Lizards from Pod Mrčaru

In the winter of 2007 a group of researchers from several universities and research institutions like: The department of evolutionary biology and biology of organisms from Harvard, The Department of Biology from the University of Antwerp in Belgium, The Royal Institute of Natural Sciences from Belgium, The Department of Zoological Museum of Natural History from Croatia and The Department for Biology and Evolutionary Biology at the Amherst University in Massachusetts (USA) presented results of a study that was conducted on period of 36 years; research was aimed at highlighting the rapid evolutionary divergence, at a large scale, of the morphology, performance and behavior associated with the exploitation of different sources of diet and distinct predation pressure.

Thus, researchers accompanied by Nevo and his colleagues changed the location, in 1971, of 5 pairs of lizards (5 males and 5 females) from the species Podarcis Sicula found in the small island of Pod Kopište (0.09 kilometers) to the neighbor islet Pod Mrčaru (0.03 square kilometers) situated about 4.2 km away from it. The conclusions reached by the group of researchers are the following: "*Although rapid adaptive changes in ecological time scale are now well documented in natural populations, the effects of these changes on the ability of whole body performance and environmental impact on the population dynamics are often unclear. In this study we show how lizards have rapidly evolved differences in head morphology, bite strength, and digestive tract structure after experimental introduction into the wild again. Despite the short time scale (approx. 36 years) from this introduction, these changes in morphology and performance are similar to those found in species and families of lizards studied that were the same type and had the same area of specialization. Moreover, these dramatic changes in population density and social structure, provide a compelling example of how the invasion of new habitat, may result in multiple directions of the phenotype evolution.*" (Herrel and others).

Conclusions were drawn by comparing lizards left on the islet

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of Pod Kopište, that probably also evolved in this 36 years but in a undirected direction therefore with insignificant consequences, with the lizards from the island of Pod Mrčaru that were subjected to a totally different environmental pressure. The comparison criteria were the differences in morphology, performance, social structure and population density due to exploitation of different food sources on one hand, and the differences in danger escape behavior, capacity and loco-motor performance, and morphology caused by different intensities of pressure between the 2 islets on the other hand.

Podarcis Sicula, the so-called Italian wall lizard, is a robust lizard that lives on the ground, is heliothermal (gets heat from sunlight), actively seeks food and is part of the family of lizards Lacertida that occupies a series of semi-open habitats in the Mediterranean area. These lizards reach maturity in about a year. Females produce about 5 nests of 2-7 eggs each year. A significant criterion for morphological classification of this lizard is the distance from nose to anus (snout-vent length - SVL) which normally covers the range of 55-70 mm.

Fig.1 - P.Sicula , Sardinia, April 30, 2001, Per Blomberg

Fig.2 - P.Sicula , Sardinia, April 30, 2001, Per Blomberg

The two islets situated in the southern Croatian Adriatic Sea near the larger island named Lastovo, differ at first glance in the structure of the vegetation. Both islets are surrounded by an outer belt of rocks with vegetation present in small and very small amounts, and a central part that that on Pod Mrčaru abounds in all kinds of plants. Thus, on the islet we can find plants like Lavatera arborea, Lotus edulis, Portulaca oleracea, Allium ampeloprasum and Cynodon dactylon in the center while at the periphery we discover Crithmum maritimum (Fig. 3a). On Pod Kopište we find small shrubs like Pistacia lenticus and Juniperus excelsa that cover the entire area; the center part of the islet is covered mainly by Chenopodium murale, Cynodon dactylon and Aspargus officinalis, while at the periphery we find Crithmum maritimum (Fig. 3b). From the two images it can be inferred that although on Pod Kopište the flora is somehow existent the general nature of this islet is of a barren, open and arid one, while the distinguishing

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Divergent evolution due to different sources of food resources

The experimental results show significant differences in head morphology between the populations of lizards from the two islets; the heads of the Pod Mrčaru lizards (male, female, juvenile) are significantly higher, wider and longer than the heads of the Pod Kopište ones (Fig. 5), so consequently they have a greater bite force, force required for effectively chewing leaves. Dissections performed on lizards show that specimens with enlarged heads have a diet that consists of many more plants than those with smaller heads. Stomach analysis shows significant differences between seasonal diets of the lizards from the Pod Mrčaru islet, which consists of 34% plants during spring and 61% plants during summer from the total vegetable food consumption. Clarifying is the fact that the lizards on Pod Kopište have a quantity of plant food consumption that is 4% during spring and 7% during summer, and there were no differences between diets depending on the season (Fig. 6). Moreover, about 50% of consumed plants (leaves and stems) of lizards from Pod Mrčaru have an elevated content of cellulose which explains the dramatic evolution of new intestinal morphology

Fig.3a - Pod Kopište

Fig.3b - Pod Mrčaru

of these specimens. Thus, the study indicated the presence of so-called cecal valves (Fig. 8) on all lizards of this islet, including in a fresh out of the egg specimen(SVL = 26.4mm) and a very young specimen (SVL = 33.11). These cecal valves more than resemble valves encountered in other species and families of lizards, but surprisingly are not observed in normal species of Podarcis Sicula. The purpose of these valves is to slow down the passage of food through the intestine and to provide the chambers of fermentation, which contain symbiotic micro-organisms, sufficient time to convert cellulose into volatile fatty acids that can then be easily processed by the digestive system. Again, surprisingly, nematode worms capable to do this type of processing were found in significant numbers at the end of the digestive tract of lizards from Pod Mrčaru, but was not present in specimens from the Pod Kopište islet.

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for the purpose of the study, dramatic changes were observed in the behavior of lizards due to changes in diet, and thus of the pressure that the absence or presence of large quantities of food may have had on them. Due to the abundance of food plant on Pod Mrčaru and its location and availability predictability in the near future, it was observed that the density of lizards in areas rich in resources is significantly greater than the density of lizards on Pod Kopište. Moreover, the lizards from Pod Mrčaru have ceased to protect their territories. Because of the transition from an active/hunting style of food gathering towards a passive, grazing one , the lizards hind limbs decreased in length along with a decreasing sprint resistance and decreasing maximum sprint speed, sprint scores which lizards from the Pod Kopište islet still enjoy.

Divergent evolution due to different intensity of predation pressure

Although the two islets are similar in the general physiognomy (size, height, micro-climate) and the fact that there are no terrestrial predators, the observations made by the researchers expose us, as we already have mentioned, on the one hand the predominant vegetative nature of Pod Mrčaru that is in complete contrast with the arid Pod Kopište, a characteristic that can provide additional protection against aerial predators of any kind, and on the other hand the study exhibits a very important fact, namely that it is possible that these predators visit with a reduced frequency the islet of Pod Mrčaru because of the difficulties encountered in the past trying to hunt for lizards and/or because these predators are constantly chased by yellow-legged gulls that are found in much greater numbers than on Pod Kopište; these gulls very likely have chosen Pod Mrčaru because the thick vegetation provides additional protection to nests that seagulls have to leave from time to time when they need to hunt.

Scientists have demonstrated that lizards are attacked less frequently by aerial predators on Pod Mrčaru by building 569 realistic models of P.Sicula lizards, made from no-toxic plasticine, distributing them on the 2 islets and then counting the total number of beak-bite/model or noting that the models are completely destroyed (Fig. 7a, Fig. 7b).

These relaxed conditions of predation that the lizards from Pod Mrčaru enjoy have not left their expected effects. Observations show that the specimens from this islet have maximum sprint speeds lower than those on Pod Kopište, also noted is that the strength of these lizards is generally lower than those of the neighboring island. A remarkable fact is the bigger overall size of the lizards, and paradoxically, the lower hind leg length compared to that of their counterparts on Kopište.

As it can be seen in Fig.7c lizards on the arid islet run shorter distances when approached by potential predators in areas with dense

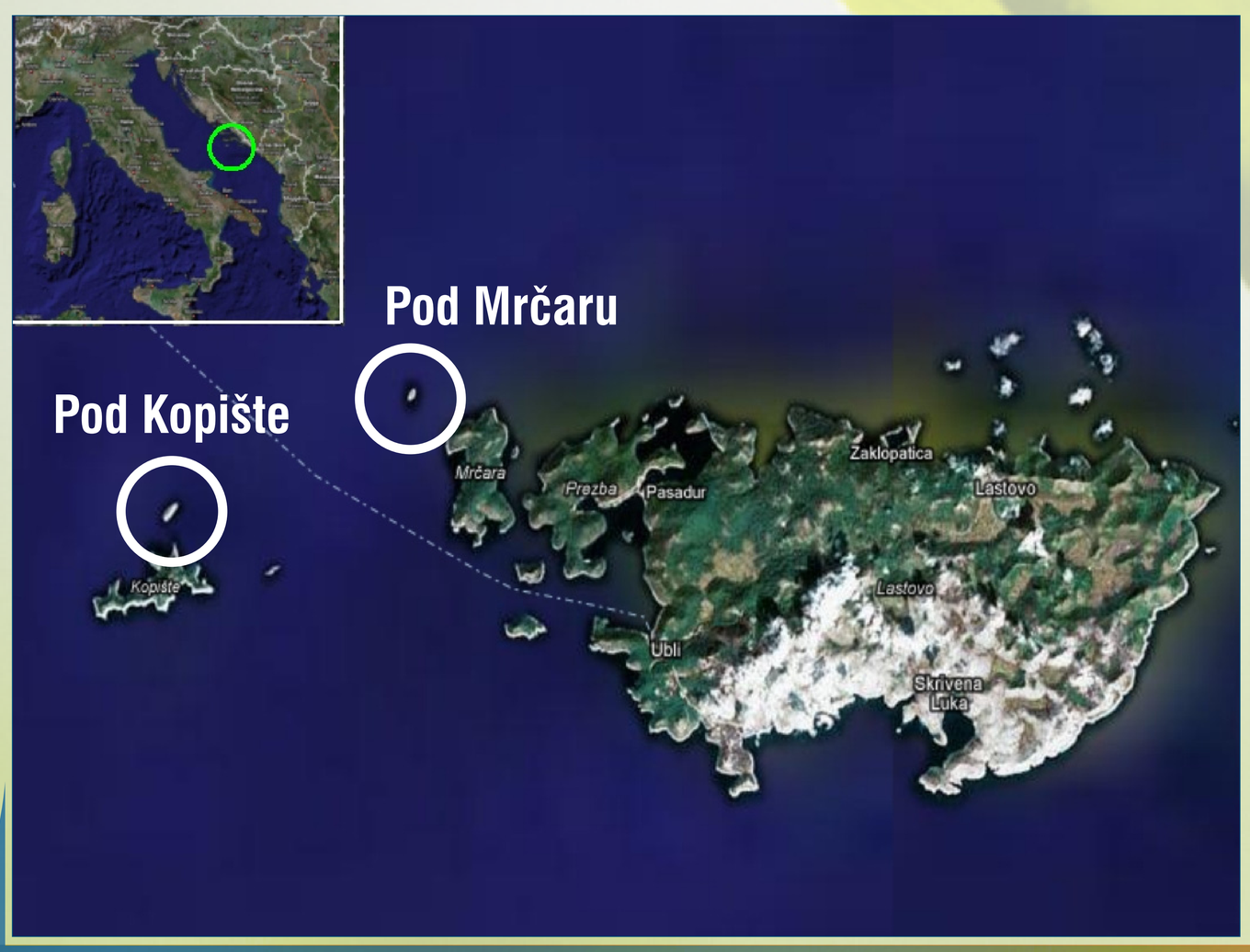
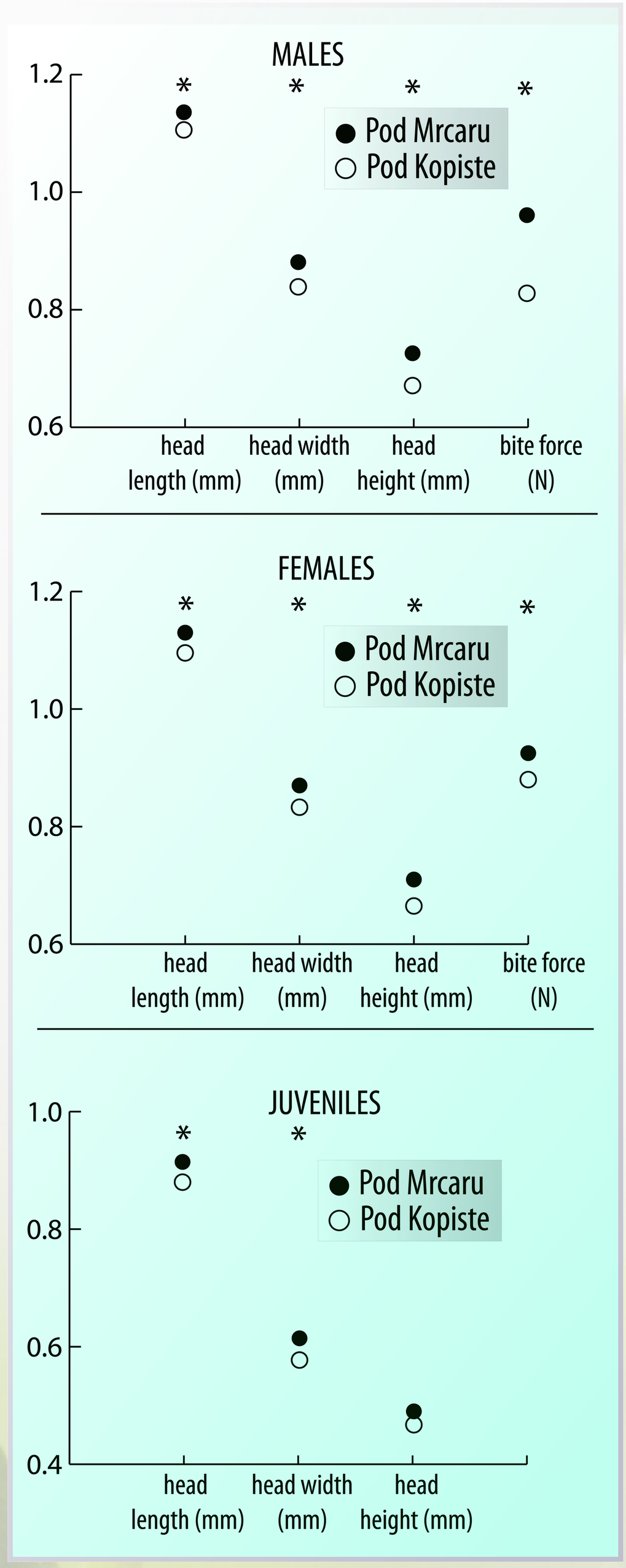


Fig.4 - Pod Mrčaru, Pod Kopište

any benefit, any adaptive adjustment that confers to a biological organism a certain advantage/ adaptation in the natural environment, does not manifest itself on the organism without the latter not paying a price for that favor



Differences in head morphology and bite force between the lizards of the two islets (logarithmic graph). The asterisk represents the significant differences. (Herrel and others)

Fig.5 - Differences of morphology

vegetation. On Pod Mrčaru specimens attacked in the areas rich in vegetation tend to leave the locus of potential danger much earlier and to stop their escape a lot later. But the most telling difference is that the lizards on Pod Kopište leave the area of danger much earlier, they spread way farther and they stop from their the escapades much later than the specimens from Mrčaru.

The conclusions of the research group highlight the existence of differences between the constraints caused by aerial predators on the two islets, despite the surprisingly small geographic scale of the region they fall in, differences that are responsible for the performance, morphology and behavior of the predated populations of lizards.

Explication - The Why and How

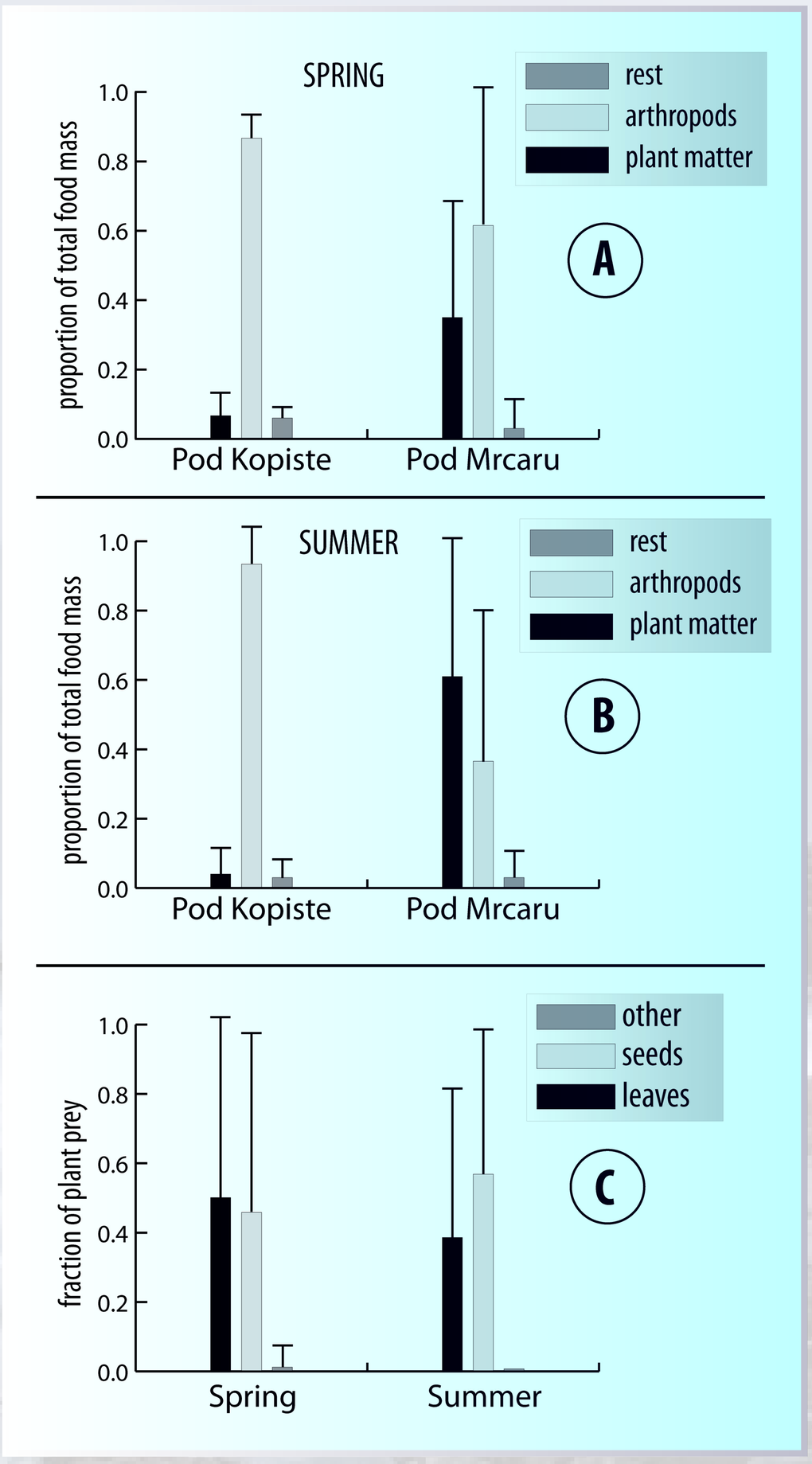
A well-known law in physics and with widespread applicability in almost all sciences says: "*In a closed system the total energy of the system remains constant*". This law also remains valid in the study of natural processes and can be translated, for it being a more enlightening tool, to: "*In a closed biological system, any benefit, any adaptive adjustment that confers to a biological organism a certain advantage/adaptation in the natural environment, does not manifest itself on the organism without the latter not paying a price for that favor*". We will use the rule above, dear friends, to see how mother nature makes exchange, negotiates with each living organism a wide range of benefits that may have various useful properties one of that being that it may represent the ticket to survival.

"*What-if?*" Is a question we should learn to ask ourselves more often if we want to understand the structure of biological phenomena, a tool that will help us to transcend time and repeat as many times as required the film of events that helps us visualize the causes, effects and logic nature takes decisions on. What if, 36 years ago, instead of Pod Mrčaru we chose another islet much larger in size but equally uninhabited by terrestrial predators and with the same physiological and micro-climatic conformation . And what would happen if, instead of putting on the island only five pairs of Podarcis Sicula, approximately similar in characteristics,

the first 100 that will gather the most resources (that will consume the most food) and manage to copulate(have sex) the most amount of times, all with a minimum of energy expense, within 24 hours as long as we conventionally chose the time of the competition, will be spared ...

we would put not five, but hundreds, thousands, tens of thousands of lizards from this species that, before landing then on the island, in our super-technological laboratory, we would equip them with various physiological,cognitive and behavioral features, that would make each individual unique, unmistakable. Obviously that from the feature sets each lizard will acquire, though unmistakable, those sets will be more or less similar to the feature sets of other lizards. So we will have a population of specimens that in some respects will resemble more or less each-other. For example, some specimens will have longer legs, others shorter, some will have a more aggressive behavior, others a more fluent and peaceful one, some will sprint twice as more than the average population, others less, of course, all these new talents being added to the lizards by our genetic engineers. And now imagine that we make a contest, namely, from the 100,000 say lizards introduced to the island, the first 100 that will gather the most resources (that will consume the most food) and manage to copulate(have sex) the most amount of times, all with a minimum of energy expense, within 24 hours as long as we conventionally choose the time of the competition, will be spared from extermination and will be left on the island by researchers, while the rest will be used as food by the same scientists.

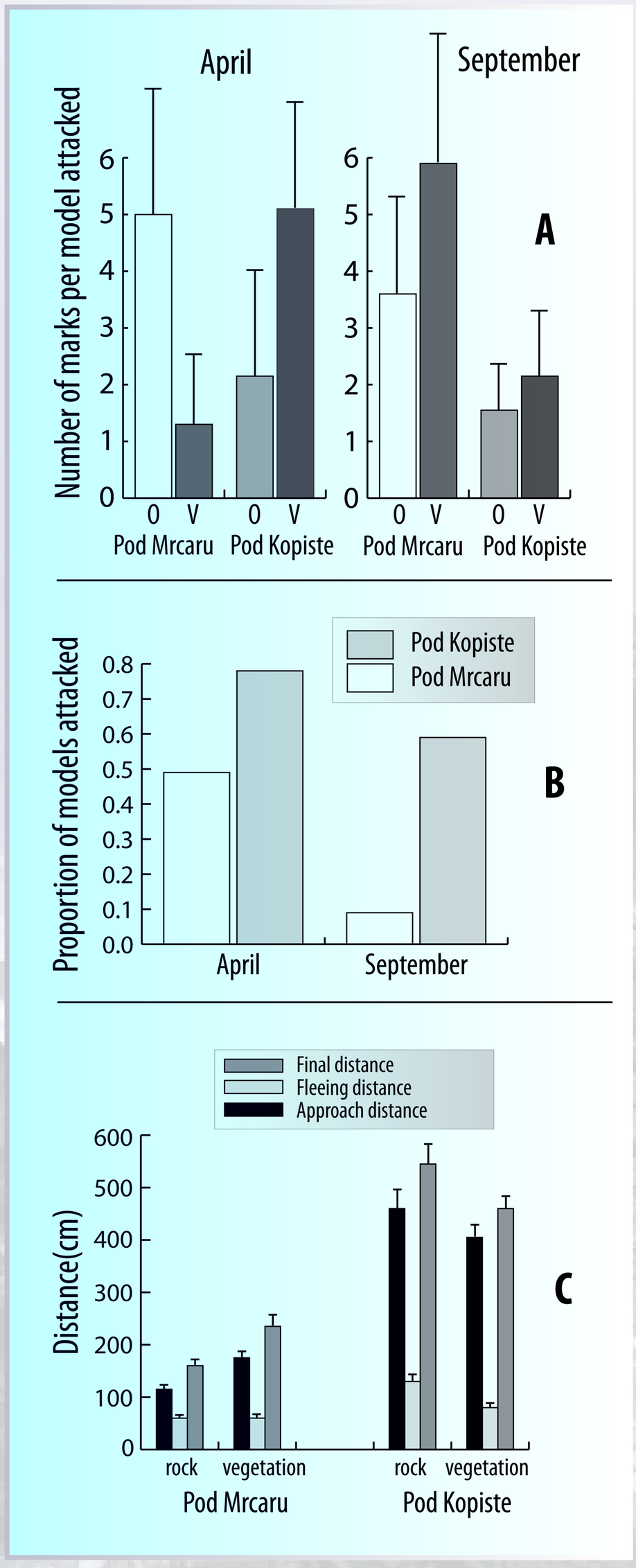
What will we observe? We'll see for example that the specimens which hunt less arthropods/insects, therefore consuming less energy, and that eat more plant food because they can digest more efficiently this type of food, ability of course imprinted in the lizard body by our laboratory specialists, will collect more resources than lizards that in general hunt insects and therefore consume more energy. Moreover, the vegetarian specimens which have bigger heads and therefore greater bite force will be able to process more leaves that are rich in cellulose and will accumulate more resources. Males that will consume more food will be more fit, and therefore in the eventual confrontation initiated in general by rivals (who had the misfortune to be equipped with a small bite force, with the digestive system without cecal valves used for efficiently digesting cellulose, with cognitive and metabolic mechanisms that predispose them to energy



(A / B) Differences between diets in spring and summer. Differences between the consumption of plants and invertebrates are highly significant between the two islands. **(C)** The fraction of plant-type of the lizards on Pod Kopiste consisting of leaves, seeds and other plants. (Herrel and others)

Fig.6 - Differences between diets

Genotypes that invest the chemical and organic energy, in the creation of lizard organisms with the adaptations mentioned above will find themselves with an increasing frequency in the gene pool of the island.



(A) The number of traces / model attacked. (0 = open area, V is predominantly vegetative zone)
(B) The difference between the pressures of predation between the two islands.
(C) Differences between anti-predation behavior. (Vervust and others)

Fig.7 - Predation pressure / Behavior

expenditure on territorial disputes and the pursuit of mobile food because they can process efficiently and quickly only that type of food), will tend to win confrontations with them and so will be selected for mating by females with a higher frequency, because they will be considered more attractive due to the fact that they are better adapted to living on this type of island than the rest of male lizards, and therefore they will again be successful in the race for survival. In this competition chance is not the driving force but design, the design of the bodies of the lizards.

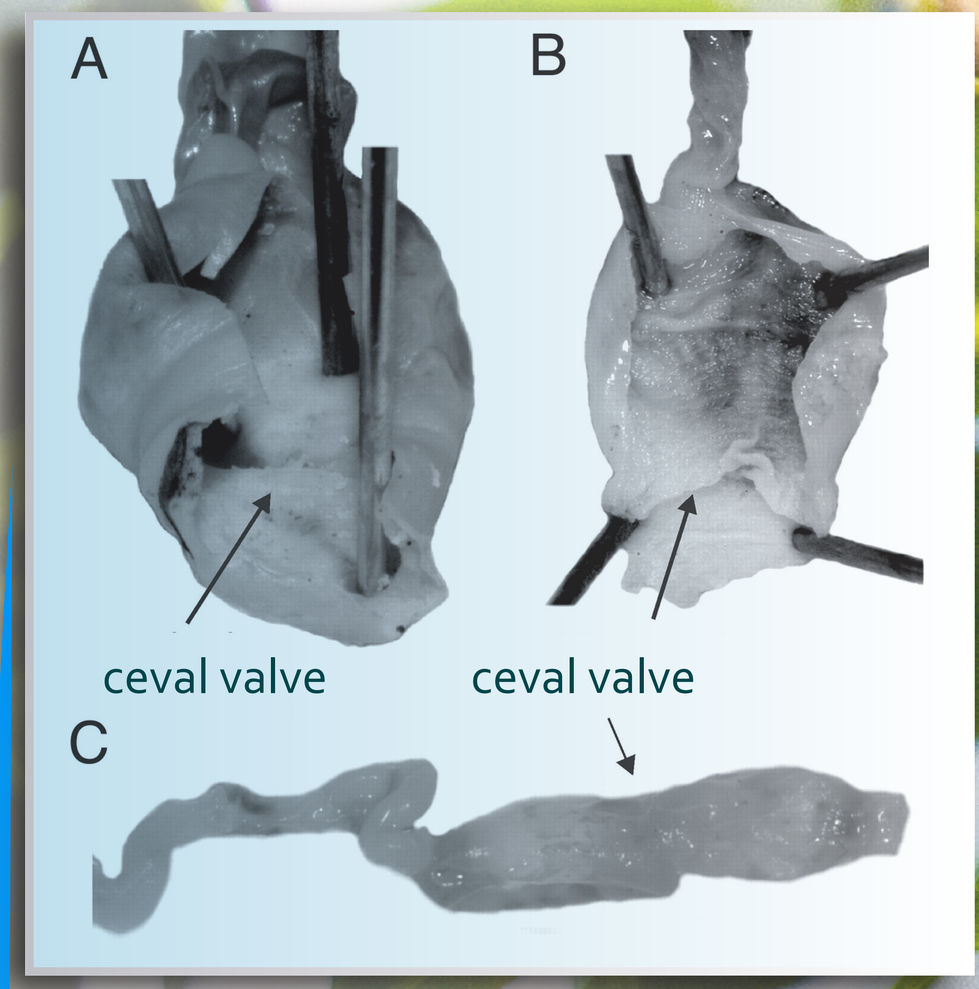
This algorithmic, mechanistic, ruthless competition is a fictional one, but it is an exercise of imagination that helps us visualize how certain individuals who have certain physiological and behavioral traits, may, in a particular natural environment, be prevailed over those who do not have these adaptations.

Although this competition does not exist, there is as a mechanism, in the universe we live in, called natural selection, that not by chance is the cause for which we homo sapiens exist, which is the equivalent of this competition. The only difference between this mechanism and the above contest is the time scale on which it is conducted and how bio-entities enter the scene. The place of the super-technological laboratory and the researchers is taken by the embryonic system present in each female lizard and the recipe code by which this system fabricates the organism, organism that is thrown into the theater of life to take the best chance at its DNA preservation in the generation that follows. DNA is a long chain composed of sequences of adenine (A), guanine (G), thiamine (T) and cytosine (T), the four types of nucleic acids each animal or plant genome is made of. The duration of 24 hours will be replaced in our case with the 36 years during which tens of generations of lizards, vehicle bodies programmed by the DNA replicator for its own preservation, will bet their luck every day to win the race for the future benefit of the sequence of nucleotides, sequence that is the only structure which is to remain intact over the long passage of time.

I mentioned a little while ago the fact that no adaptation appears inside an organism without

it not spending sufficient energy to pay for that adaptation. Genotypes that invest the chemical and organic energy, in the creation of lizard organisms with the adaptations mentioned above will find themselves with an increasing frequency in the gene pool of the island. For example if a particular gene or gene complex invests the energy that was supposed to be spent on the creation of longer hind legs that are unnecessary on Pod Mrčaru and therefore on our island , creating a larger and more powerful head will produce more adapted lizard organisms that will have more offsprings, which in turn will inherit this gene. All this genetic driven routing of energy consumption towards creating adaptations tends to multiply in the population the gene for those adaptations.

If the above story has the gift to show us how in only 36 years evolution can produce such dramatic changes in the phenotype of a particular species, let us imagine what might happen in one hundred, one thousand, one million, or not why in the age of our mother planet, in 4.6 billion years. The result is the movie of our appearance on earth, a long movie beginning with stable physical and chemical structures that start occurring in the primordial soup, passes through unicellular complex constructs that we can begin to attribute some of the properties of life, and finally reaches biological entities that can contemplate at the causes of their existence.



CECAL valves in a male (A), a female (B) and a fresh out of the egg specimen (C) of the species P. Sicula from Pod Mrcaru. You can view the thick cecal wall and the pronounced notches. (Herrel and others)

Fig.8 - Cecal valves

References

[1] "The Greatest Show On Earth - The Evidence for Evolution by Richard Dawkins
> GET REVIEWS HERE - http://www.amazon.com/gp/product/1416594787?tag=scite03-20
[2] "The Selfish Gene: 30th Anniversary Edition - by Richard Dawkins
> GET REVIEWS HERE - http://www.amazon.com/gp/product/0199291152?tag=scite03-20

[3] "Rapid large-scale evolutionary divergence in morphology and performance associated with exploitation of a different dietary resource" (Herrel et al) :
http://www.pnas.org/content/105/12/4792.full
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2290806/
http://www.bio.umass.edu/biology/irschick/Irs_papers/Herrel%20et%20al%202008%20PNAS.pdf
[4] "Differences in morphology, performance and behaviour between recently diverged populations of Podarcis sicula mirror differences in predation pressure" (Vervust et al) :
http://www3.interscience.wiley.com/cgi-bin/fulltext/118531892/PDFSTART
http://webhost.ua.ac.be/funmorph/publications/Vervust%20et%20al%202007%20Oikos.pdf