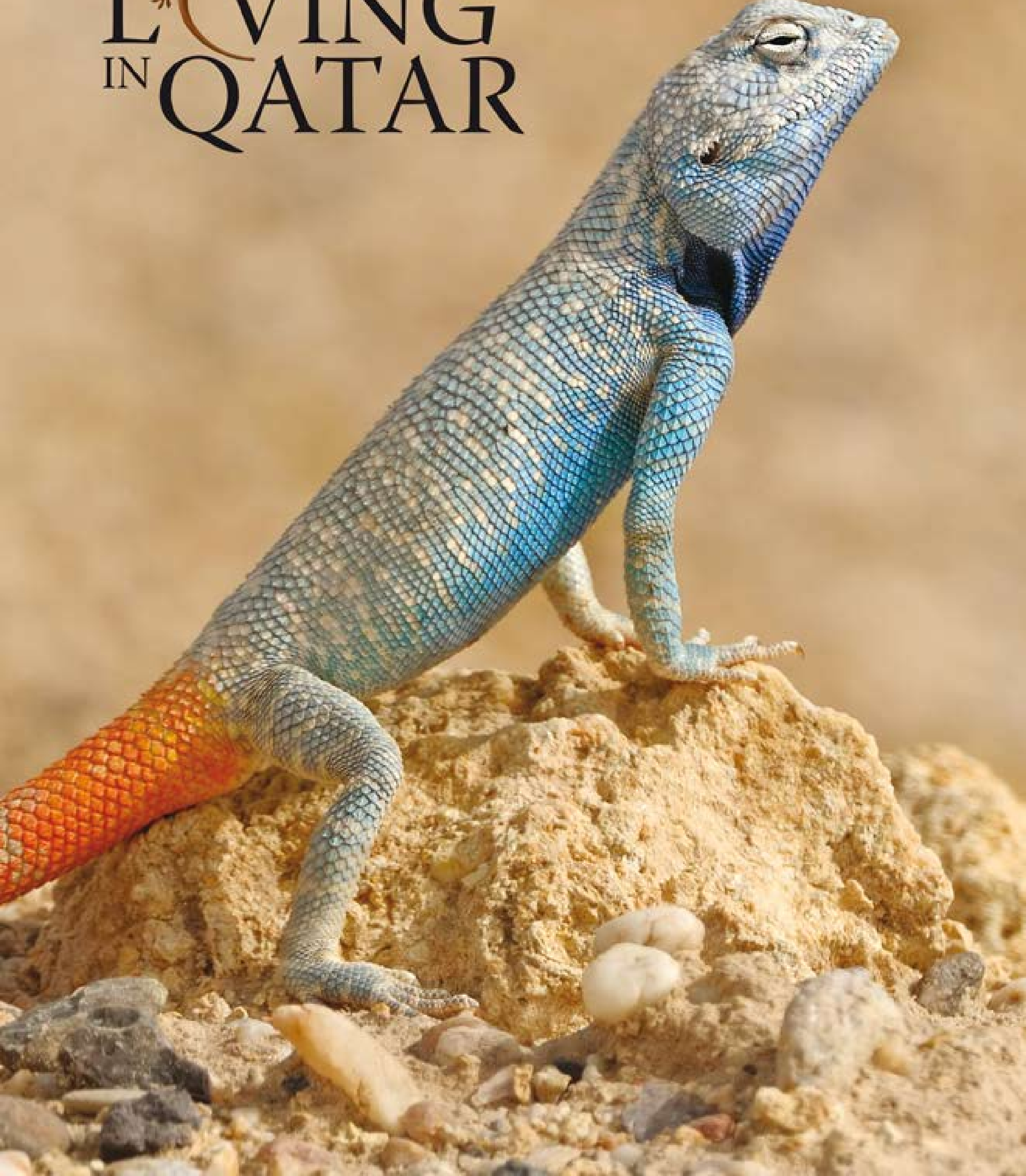
THE LIZARDS LIVING IN QATAR



State of Qatar
Ministry of Environment

THE LIZARDS LIVING IN QATAR

State of Qatar

This book is dedicated to the people of Qatar

His Highness
Sheikh Hamad Bin Khalifa Al-Thani
Father Emir

His Highness
Sheikh Tamim Bin Hamad Al-Thani
Emir of the State of Qatar

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The most colourful lizard in Qatar
Photograph by Dileepkumar Pushpangadhan

Supporting Organizations

The following respected international and national organizations have kindly given their full support to the publication and aims of this book, The Lizards Living in Qatar

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Qatar aims to be an advanced society, capable of sustaining its development and providing a high standard of living for its entire people in the near future. The Qatar National Vision 2030, envisaged by our beloved Emir HH Sheikh Tamim bin Hamad Al Thani, is the blue print for this. Environmental development is one of its four pillars. It is said that where the quality of environment goes down, the quality of life goes down for mankind. Realising this, our wise leadership has made it clear that sustaining economic and social development is impossible without a holistic vision that places environmental preservation for Qatar's future generations at the forefront.

We need to strike a balance between developmental needs and the protection of nature, including the air, land, water or the biological diversity. We must protect our flora and fauna, and make sure our rapid development leaves minimal carbon footprints on our beautiful nature.

Plans to protect air and water, wilderness and wildlife are in fact plans to protect mankind. The fate of the living planet is the most important issue facing mankind today. In order to effectively protect our environment, we need to give adequate emphasis on establishing an effective legal framework and setting up institutions that can serve as the guardians of our environmental heritage.

We, at the Ministry of Environment, are committed to protect our environment, and co-operate with the regional and international communities to achieve this goal. In coordination with international organizations Qatar will take the necessary steps to identify the main areas of biodiversity on the peninsula, and will embark on a program to protect wildlife through conservation laws and awareness campaigns. We are also committed to start a program of scientific research to examine the biological and ecological requirements of the species, which is a basic step to proceed with conservation actions; to conduct taxonomic studies and systematic studies to identify new species, and explore each organism's responses to human activities including climate change.

We believe it is of paramount importance to engage the people of our region, especially the youth, who hold the future of this world in their hands, in all these programmes. We need you on board. Together we can make our earth a better place to live in. Believe that we have the capacity and the responsibility. We must act before it is too late.

His Excellency Ahmad Bin Amer Mohamed Al Hemaidi
Minister of Environment

This is the first comprehensive book that has ever been published worldwide on the lizards of Qatar. The authors have collected novel and updated data about the presence and distribution of the lizard species in Qatar, making scientific biodiversity data available and useful for Qatar, the Gulf region and the international community. The book shows the first distribution maps for the Qatar lizards, and they also constitute the first maps that have ever been conducted for the distribution of any animal species in the Qatar country.

The content of the book with ten chapters is described with easy words making it useful for nature lovers and the general public. It is also valuable for stakeholders, and is a reference for graduate students interested in ecology, management and scientific research. The book also aims to create public awareness and encourage the general public to contribute towards protecting the Qatar´s environment for future generations.

The reader will also find in this book valuable and enjoyable information about the Qatar country that is illustrated with excellent photographs of landscapes, habitats and plants that can be found in Qatar. High quality photographs essential for recognising and identifying lizard species in the field can also be found in the book.

This book has been produced with the efforts of a large team of scientists, students, experts and volunteers from different countries and cultures that have been working together in harmony and great passion to get it done. Eighty three percent of the authors of the book belong to Qatari institutions, fifty eight percent of the authors are Qatari nationals, and forty two percent are students. Qatari students have been given the opportunity to participate in different phases, and have learned the process of searching international literature, conducting field work, designing figures and editing photos to produce this scientific publication. They have also learned to work as a team while also interacting with experts and scientist from Qatari and international institutions.

It is part of our social responsibility to highlight the importance of protecting the Qatar environment and its wild species among nationals, residents and visitors. Many readers of this book will be encouraged to go out and discover the treasures of the Qatari desert and national heritage.

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"Excellence with the Ministry of Environment"

I
INTRODUCTION

Introduction

Importance of conserving Biodiversity

Biodiversity is part of the heritage, culture and future of Qatar. It is also essential for sustaining life, for national and cultural identity, to provide grounds for scientific and medical research, and to acquire positive international recognition and international press. Biodiversity needs to be conserved over time, while striking a balance with the need for economic growth. In the Qatari culture, nature conservation is understood to be a religious and moral duty, and an imperative commanded by Allah (QGSDP, Qatar General Secretariat for Development Planning 2011).

In Qatar, as in many other countries, biodiversity is facing threats from a range of human activities. Population growth and rapid urbanization, together with the effect of global warming, have put pressure on the delicate balance of natural environments.

Optimal management and conservation of wildlife requires detailed and complete knowledge of the distribution of wild species and their populations. Distribution and ecological data accompanied by progress in computation and advanced analysis methods allows for the proper management of data based on scientific knowledge (Matin et al. 2012, Reese et al. 2005). However, without such information it is impossible to proceed with appropriate management action plans for conservation or to understand and predict the potential impacts caused by different kinds of human activities, including man-induced climate change.

Several global-scale initiatives have begun to compile vast biodiversity datasets. Some examples include the Global Biodiversity Information Facility (GBIF) and the Encyclopaedia of Life (EOL). Unfortunately, the data available in these international global databases is biased, mainly because only a few countries are contributing the majority of data. More participation from a larger number of countries is needed and required.

Current status of biodiversity knowledge in Qatar

In Qatar, many surveys have been conducted by different institutions (Ministry of Environment, Qatar University, Friends of Environment Centre) and private companies in Qatar; however their findings have yielded conflicting data and information about the recorded species and their distribution in Qatar. This is why there is an urgent need to conduct a reliable and comprehensive database of biodiversity for the country and proceed with careful monitoring of changes (QGSDP 2011). The discrepancies found in the number of species or classification of the species could also be a consequence of poor biodiversity identification skills.

Another important shortage of information concerning Qatar biodiversity is the lack of distribution maps for many of the species in the country. Without having the accurate and precise location of each species based on a global positioning system (GPS), it will be impossible to identify important conservation areas for animals and plants, to proceed with the proper management of the databases, and to model species distribution ranges.

In Qatar, most attention has been devoted to the conservation of coastal areas and marine life, while terrestrial biodiversity has been largely ignored except for some birds, plants and mammal species, with some being listed as threatened or rare species (State of Qatar 2004). However, many of the wild species in Qatar still need to be identified and given a conservation category according to their current status.

As a Party of the Convention of Biological Diversity (CBD), Qatar has prepared a National Biodiversity Strategy and Action Plan (NBSAP), clearly indicating the commitment to prioritise environmental issues related to sustainable development and preservation of biodiversity (State of Qatar 2004).

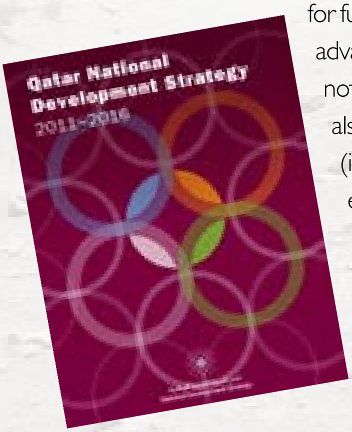
The current Ministry of the Environment in Qatar has plans from 2014 to protect wildlife and the environment and to co-operate with the regional and international communities to achieve this goal. Qatar will take the necessary steps to identify the main areas of biodiversity on the peninsula, and will embark on a program to protect wildlife through conservation laws and awareness campaigns. The new Ministry is also committed to starting a program of scientific research in coordination with international scientific institutions and universities to (1) examine the biological and ecological requirements of species; (2) conduct taxonomic and systematic studies to identify new species; and (3) explore each organism's responses to human activities, including climate change.

Alignment of the book with the Qatar National Vision 2030

Qatar's National Vision (QNV) 2030 rest on four pillars including Human Development, Social Development, Economic Development and Environmental Development. According to QNV 2030, Environmental Development implies the management of the environment in a way that there is harmony between economic growth, social development and environmental protection. A balance between development needs and protecting the environment will lead to a sustainable utilization of the environment in Qatar.

To accomplish the goals of the QNV 2030, a national biodiversity database in the country will be completed (QGSDP 2011). This book is a contribution to that goal, and presents the updated data and the first distribution maps available to date for each lizard species in Qatar.

This book is in harmony with programs set aside in the mandate issued by the Qatar National Development Strategy 2011-2016. It is directed at ensuring a sustainable environment for future generations and to identify specific actions and outcomes to advance the Qatar National Vision 2030 goals. The program includes, not only (i) the creation of the national biodiversity database, but also (ii) the enhancement of scientific research and publications, (iii) building knowledge and skills and (iv) strengthening technical education and vocational training.



Report of the Qatar National Development Strategy

Biodiversity and the feel-good factor in human populations

Over half of the world's human population live in cities, and for many, urban green spaces are the only places where they encounter biodiversity. This is of particular concern because there is growing evidence that human health and well-being are enhanced by exposure to nature, and humans respond positively to increased levels of biodiversity (Dallimer et al. 2012).

People from all backgrounds value biodiversity in different green spaces, including domestic gardens, urban parks, semi-natural habitats and true natural areas; and from which they experience clear benefits to their well-being (Irvine et al. 2010). These facts have caught the attention of many researchers and led them to conduct very interesting scientific studies. For example, increases in the amount of green space in a neighborhood are associated with improvements in human longevity (Takano et al. 2002) and self-reported health (de Vries et al. 2003). In addition, reduced mortality from circulatory diseases has also been reported (Mitchell and Popham 2008). People who visit urban parks report fewer visits to physicians (Godbey et al. 1998). Also, people who engage in exercise in the presence of nature report better improvements in mood and self-esteem than those who exercise in non-natural surroundings (Barton and Pretty 2010).

Exposure to natural environments is also associated with quicker recovery rates from surgery (Ulrich 1984), increased social interactions (Sullivan et al. 2004), increased cognitive functioning (Berman et al. 2008), reduced mental fatigue (Kuo 2001), lower crime rates (Kuo and Sullivan 2001), provision of opportunities for reflection (Fuller et al. 2007) and stress amelioration (Ulrich et al. 1991, Yamaguchi et al. 2006).

Recognition of the potential contribution of natural ecosystems to human population health may also contribute to addressing problems associated with physical inactivity, obesity, mental health issues and other chronic diseases (Barton and Pretty 2010).

Considering all of the above information together, urgent action is needed to design appropriate management programs to protect current biodiversity and increase green spaces for wildlife conservation and for human well-being. More green spaces will motivate people to enjoy outdoor activities and potentially reduce the indoor sedentary lifestyle. Such a shift could be crucially important because physical inactivity results in approximately 1, 9 million deaths worldwide annually (Barton and Pretty 2010). As aging populations put additional pressure on health services, it is urgent that all sectors of the population undertake and sustain healthy behaviors as early on in life as possible (Lim and Taylor 2005). In economic terms, long-term costs will be saved if natural places are both protected and used as sites for human physical activity, thus generating direct health benefits and improving overall well-being (Matthews and Lave 2000, Barton and Pretty 2010).

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Green areas are highly appreciated by people living in cities and we should increase them

Conserving the environment as a religious duty

The environment has become an issue of higher concern to countries at an international and regional scale because of the serious hazards that affect its components. The rapid decline of the world's biodiversity and the increasing need for natural resources to accommodate the growing population, suggest that the current western philosophy of conservation biology is not achieving its mission and objectives. Consequently, the existing religious tools and channels for conservation should be seriously considered, since there is a high potential in achieving high standards of conservation biology if management of natural resources adheres to the fundamental principles of Islam (Azad 2012).

Islamic rules and values potentially provide a very effective, practical and comprehensive solution to many of the current unprecedented environmental absurdities (Manzoor 1998).

Mischief has appeared on land and sea because of that the hands of men have earned, that (Allah) may give them a taste of some of their deeds: in order that they may turn back (from Evil) (Al-Rum 30: 41).

The Islamic foundation for an ecological ethics and moral principles rests firmly on the Al-Quran and Hadith (Statements or actions of Prophet Muhammad PBUH) where the notion on *Khalifah* vicegerent) and *Amanah* (trusteeship), shows communal obligation to the environment.

There is none amongst the Muslims who plants a tree or sows seeds, and then a bird, or a person or an animal eats from it, but is regarded as a charitable gift for him (al-Bukhari, Sahihal-Bukhari, Volume 3, Chapter 39: Agriculture).

The world is sweet and green (alluring) and verily God is going to install you as vicegerent in it in order to see how you act (Muslim, *Sahih Muslim,* Kitab al-Riqaq, Chapter 36: Heart Melting Traditions).

There is great potential for facilitating policy and methods for practising sustainable development from an Islamic perspective. Islamic tradition and values could be used as a tool to address the current state of the environment (Azad 2012). In practice, this includes incorporation of Islamic ethics in governance. Islamic Vision, and in more recent year Islamic governance 'Islam Hadhari,' which emphasizes development, knowledge and plurality within its ten principles, includes "safeguarding the environment" as a central tenet (Azad 2012).

One does not even have to be Muslim to benefit from such pedagogy which embraces justice and knowledge. Islam stresses acquiring knowledge through hearing, seeing and reasoning (Tabbarah 1988). The Quran itself puts equal emphasis on natural science, psychology, history, geography, sociology, astronomy and other fields of knowledge (Azad 2012).

The Islamic jurisprudence emphasised the need to protect, preserve and develop the environment prior to all modern legislations, regulations and international conventions for preserving the environment. Allah has set out in the Quran and the Prophet Muhammad (peace be upon him) in his Sunnah, guidelines which constitute a platform in all the affairs of life including the environment. Those include, preserving water and not wasting or polluting it, preserving plants by not cutting them unless necessary, and sowing plants to eat as grains, vegetables, and fruits. In addition, these guidelines enjoin us to preserve the animals and wildlife and rear and take care of them for the production of meat, wool and milk.

Everything on the earth was balanced before the persistent and aggressive advancement of humans towards the environment. Islam cared for the environment and emphasised the importance of maintaining all its elements. Muslims must therefore utilise the environment for their advantage and for the advancement of humanity, without causing any damage, pollution or destruction, because the environment is a grace that must be taken care of.

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Most children like animals and they should have more options to enjoy them under natural conditions

Lizards in our daily life

Lizards are fascinating and intriguing animals that are loved by many children and provide company and entertainment to many people worldwide (http://small-pets.lovetoknow.com/reptiles-amphibians/names-pet-reptiles). Lizards show a huge variation in body size from a few centimetres (e.g., geckos) to nearly three meters in the case of the Komodo dragon (Green and Dennis 1993). Small lizards have inspired great and memorable characters in movies like the Geico gecko (http://disney.wikia.com/wiki/Category:Lizards), while big lizards have inspired scary monsters like Godzilla. The public has chosen the ten top most famous lizards in folk and films (http://animals.pawnation.com/top-10-famous-lizards-8985.html).

Lizard sculptures are also displayed in public gardens, buildings and cities all across the world in orient and occident (https://www.google.es/search?q=lizard+sculptures+in+cities). The lizard ability of sticking on the wall has been taken by the German car company Wiesmann to highlight the performance of their cars that sticks to the road, and the logo of the company is a gecko (http://www.car-logos.org/wiesmann-car-company-logo). The state of Texas in USA designated the Texas threatened horned lizard (*Phrynosoma cornutum*), the official state reptile in 1993, and this is still nowadays the symbol of the State (http://www.statesymbolsusa.org/Texas/Texas_Horned_Lizard.html). This is a very common souvenir that many tourists buy in USA.

Many people enjoy drinking their coffee in lizard mugs. Also, the refrigerators in many houses all over the world have magnets with lizards because they are a symbol of good luck. The lizard eyes are extremely variable and have always fascinated the general public in different countries, to the extent that lizard contact lenses with amazing bright colours are commercially available in many shops around the world (http://www.youknowit.com/online-shop/reptile-eyes-contact-lenses.cfm).

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Lizard from the artist Gaudi in Park Guell, Barcelona (Spain)

Logo of the German car company Wiesmann

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The lizard symbol of the State of Texas in USA is on the table of many offices around the world

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Coffee mug with a Qatar lizard

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Lizards are a symbol of good luck and are displayed in many houses

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Lizard calendars are also displayed and used by nature lovers

Lizard applications to scientific research and medicine

Many animals are used by scientists to advance science and technology. For example, Velcro was inspired by the grappling hooks of plant burrs. Supersonic jets have structures that work like the nostrils of peregrine falcons in a speed dive. Full-body swimsuits, now banned from the Olympics, lend athletes a smooth, streamlined shape like fish. Lizards also feature in scientific research and many successful results have been obtained from these studies. Some examples are indicated below.

NANOTECHNOLOGY

The amazing climbing ability of geckos has attracted the interest of scientists for centuries. Geckos use nanoscale structures on their feet to accomplish gravity-defying feats like hanging upside down from polished glass. However, only in recent years has progress been made in understanding the mechanism behind this ability, which relies on submicrometre keratin hairs covering the soles of geckos. Each hair produces a miniscule force but millions of hairs acting together create a formidable force of adhesion that is sufficient to keep geckos firmly on their feet, even when upside down on a glass ceiling (Geim et al. 2003). Gecko-like synthetic adhesives may become the glue of the future (Autum and Gravish 2008).

Scientists have created a prototype of 'gecko tape' made by microfabrication of dense arrays of flexible plastic pillars, the geometry of which is optimized to ensure their collective adhesion (Geim et al. 2003). With lizard feet in mind, scientists have also created a biocompatible medical adhesive that features a pattern of nanoscale pillars to maximize contact area. The material can stick to a variety of tissue surfaces, including those that are irregular and change shape.

The origin of the high adhesive forces of gecko feet to water could be attributed to the high density nanopillars that contact the water. Inspired by this, polyimide films with gecko-like multiscale structures have been constructed by using anodic aluminum oxide templates, exhibiting superhydrophobicity and a strong adhesive force towards water (Kesong 2012).

Scientists have also been inspired by geckos for the production of medical adhesives with potential applications for sealing wounds and for replacement or augmentation of sutures or staples (Mahdavi et al. 2008).

The strong attaching and detaching ability of geckos has become a hot point in scientific research for the huge potential applications for producing several gecko-like materials or apparatuses (Persson 2003, Wenwu et al. 2009). A detailed understanding of the underlying mechanisms governing the material properties and adhesion performances is critical to the design and fabrication of gecko inspired dry adhesives of practical significance.

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Without geckos in mind, it is possible that humans would never have invented adhesive nanostructures. Leg of the yellow-bellied house gecko *Hemidactylus flaviviridis*

The micro ornamentation of some lizards yields a super hydrophilic surface, and the semi tubular capillaries allow for an efficient passive or directed-transport of water (Baumgartner 2012). Several lizard species that live in arid areas have developed special abilities to collect water with their body surface and ingest it. The water can originate from humid air, fog, dew, rain or even from humid soil. The skin and scales of lizards have developed features so that the water spreads along their entire body surface and is soaked into a capillary system in between their scales. Within this capillary system the water is transported to the mouth where it is ingested. This rain- or moisture-harvesting by lizards has been investigated by scientists with applications to nanotechnology (e.g. Baumgartner 2012).

By investigation of individual scales and by characterising and producing polymer replicas of the reptiles' integuments, scientists have found that the honeycomb like structures render the surface superhydrophilic, most likely by holding a water film physically stable. Furthermore, the condensation of water from humid air is improved on this surface by about 100% in comparison with unstructured surfaces (Baumgartner 2012).

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The Qatar lizard *Phrynocephalus arabicus* has the ability to harvest water from the environment

Biological surfaces (e.g. lizard and insect attachment pads, fish scales, plant leaves) have remarkable properties due to their hierarchical structure. Multiscale organization of the biomimetic surfaces and their adaptation to capillary effects make them suitable for applications using new principles of energy transition (e.g. capillary engines) and environment-friendly technologies (e.g. self-cleaning oleophobic surfaces) (Nosonovsky and Bhushan 2009).

HYDRODYNAMICS

Physicians interested in hydrodynamics use lizards to understand their theories. For example the basilisk lizard (*Basiliscus basiliscus*) runs along the water surface supporting their body weight by slapping and stroking into the water with their feet (e.g. http://www.youtube.com/watch?v=JF-UMgdkph4). The foot motions exploit the hydrodynamic forces of low-speed water entry. This offers great opportunities to scientists to measure the impact and drag forces for objects dropped into water and the period during which the air cavity behind the object remains open to atmospheric air (Glasheen and McMahon 1996).

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The lizard *Basiliscus basiliscus* has the ability to run on the water. This lizard does not occur in Qatar

DIABETES AND CRAVING TREATMENTS

The saliva of a large venomous lizard native to the southwestern United States and northwestern Mexico, the Gila monster (*Heloderma suspectum*), has been used to treat diabetes (e.g., Furman 2012). In 2005 the Food and Drug Administration of the United States approved a drug for the management of Type 2 diabetes, Byetta (exenatide), a synthetic version of a protein derived from the saliva of the lizard. Researchers at the Sahlgrenska Academy at the University of Gothenburg in Sweden have now found an entirely new and unexpected effect of the lizard substance in their saliva that reduces cravings for ordinary food. The drug elaborated from the saliva of the lizard has been tested on rats, which after treatment ceased their cravings for excessive food and chocolate.

The implications of the findings are quite significant, according to Suzanne Dickson, Professor of Physiology at the Sahlgrenska Academy, since most dieting fails because of peoples' desire to eat, especially sweets. As exendin-4, the hormone that occurs naturally in the saliva of Gila monster lizard, suppresses the cravings for food, it can help obese people control their weight. Conducting this type of research gives hope for new ways to treat diseases related to eating disorders, such as compulsive overeating, and to reduce the craving for alcohol. Because the same brain regions are involved in food and alcohol cravings, it would be very interesting to test whether exendin-4 also reduces the cravings for alcohol, as suggests by Professor Skibicka at the Sahlgrenska Academy.

The saliva of Gila monster (*Heloderma suspectum*) has been used to cure diabetes.
This lizard does not occur in Qatar

AUDITORY TREATMENT

Many patients suffering auditory neuropathy and temperature-dependent hearing loss are known in human populations. The relationship between temperature and hearing loss is of great interest among scientists, and lessons from animal morphology and physiology help doctors to finding solutions to provide cures to their patients.

The worm lizard (*Diplometopon zarudnyi*) that inhabits Qatar and other members of the amphisbaenian group have been used by scientists to explore high levels of auditory sensitivity because they show a distinctive form of sound-receptive mechanism. An additional peculiar feature of these lizards is the degree of stability of the ear's responses in the presence of large variations in body temperature. There are many scientific publications that examine these aspects (e.g. Baird 1970, Manley 1981, Christensen-Dalsgaard and Manley 2005).

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The fossorial legless worm lizard (*Diplometopon zarudnyi*) that lives underground in Qatar, has a special sound-receptive mechanism and high levels of auditory sensitivity

ORGANS REGENERATION

Lizards have the ability to regrow their tails (Ramachandran et al. 1996), but humans, despite the advancements in science lack this superpower-like ability. The fact that lizards can regenerate cartilage skeleton and make brand new muscle is of continued interest to scientists who believe learning more about regeneration could be beneficial to humans in the future.

Using next-generation technologies, scientists hope to unlock the mystery of what genes are expressed when the lizard's tail regrows. Professor Kenro Kusumi from the Arizona State University School of Life Sciences believes that by supercharging these genes in human cells it may be possible to regrow new muscle or spinal cord in the future. Jeanne Wilson-Rawls from the same university also indicates that more studies using animal morphology and histological data are needed for understanding how new cartilage and muscle are produced by lizards, and highlight the urgent need to better understand the molecular and cellular basis of this regeneration. Scientific research will help lead to discoveries of new therapeutic approaches to spinal cord injuries and diseases such as arthritis.

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Lizards have the ability to regenerate their tails. Double tail in the lizard *Mesalina brevirostris* found in Qatar

LIZARD VENOM AND TISSUES USED FOR DRUGS

Lizard venoms have long been recognized as a rich source of biologically active molecules with the potential to be mined for the discovery of drugs (Aramadhaka et al. 2013).

Komodo dragon lizards, like cobras, are immune to their own venom. Like all biological defences, this has possible applications in medical research. If scientists can find the antibody in Komodo blood that renders it immune to its own bacterial cocktail, then it could lead to a new class of antibiotics. In 2004, scientists discovered the antibody in cobras that blocks the effects of cobra venom. They believe that understanding how the venom receptors are blocked in these animals could lead to improved treatments for heart attacks (http://science.howstuffworks.com/zoology/komodo-bite.htm).

Reptile venoms are complex cocktails of bioactive molecules, but the drug discovery potential of most species remains unrealized. This is because of the scarcity of scientific studies, because many populations and species are disappearing, and because many species are endangered and protected by law. However, scientists are describing how potential clinically important bioactive peptides and their corresponding mRNAs can be structurally characterized from single, small samples of lizard venom in order to progress in science and medicine while contributing to biodiversity conservation (e.g. Chen et al. 2006).

The skin of some lizards (*Ameiva ameiva*) that live in semi arid zones of Brazil have some compounds with proven antimicrobial activity, and are promising sources of new drugs with antibiotic properties (Santos et al. 2012). The medicinal efficiency of lizard species of the genus *Tropidurus* has been shown for the treatment of bacterial infections such as tonsillitis and pharyngitis (Santos et al. 2012). The oil of the fat bodies of the lizard *Tupinambis merianae* provide remedy for skin diseases such as dermatitis (Ferreira et al. 2010).

Using colorimetric assays and immunohistochemistry it has also been shown that extracts from geckos have an inhibitory effect on proliferation of esophageal carcinoma cells (Wang et al. 2010).

The dramatic decrease of lizards in China in recent years due to habitat destruction has resulted in more adulterants in traditional medicine, and scientists are employing the molecular method of DNA barcoding for discriminating *Gecko gecko* from its adulterants and to identify the Chinese crude drug gecko (Gu et al. 2011).

Lizard usage as traditional medicine in rural areas

Several lizard species are commonly used in traditional medicine in rural areas of many countries around the world, and at least 14 species of geckos are utilized as ingredients in the pharmacopeia of traditional medicine systems (Bauer 2009). Data shows that Taiwan alone has imported 15 million geckos for medical purposes since 2004 (http://phys.org/news/2013-04-asian-gecko-threatened-medicine.html#jCp). This has important negative consequences for the stability and conservation of many lizard populations.

Chinese Traditional Medicine has been using different species of geckos (e.g. *Gekko gecko, Hemidactylus* spp.) for over 2000 years to treat a diversity of ailments including asthma, tuberculosis, diabetes and cancer. Current research in China is still focused on the identification of active ingredients in geckos (Bauer 2009). Although many patents have already been published, more scientific proof is needed to verify the efficacy of the drugs; particularly before sacrificing lizards with no proven curative properties.

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Female Dhub (Uromastyx aegyptia) in Simaismah, Qatar

In many Arab countries, eating the Dhub (*Uromstyx aegyptia*) has been traditionally considered beneficial for health and body strength. It is mainly believed that the meat increases the sexual drive of man, especially by eating the tail, and many other beneficial attributes are also associated to Dhub consumption, even though there is no scientific evidence for its efficacy in this regard. Aged people believe that the Dhub's oil is good for arthritis, back pain, and bones in general. It is believed that the Dhub meet reduces diabetes, improves vision, and prevents eye disease, such as cataracts. Moreover, the meat is believed to help get rid of bladder stones and prevent thirst for a long period. Eating the Dhub's spleen is believed to be beneficial for the human spleen, and eating the Dhub's heart is believed to improve human longevity because it functions as an antioxidant. Consumption of the heart is also believed to take away sadness.

Drinking the Dhub blood is believed to be good for asthma. Blood has also been used to treat eczema and psoriasis because it is believed that the plants consumed by the Dhub and incorporated in their circulatory system are beneficial to cure those affections. In fact, the Dhub is called by locals a "walking pharmacy". The blood is spread over the affected human skin mixed with the Al Thamer plant.

To date, no scientific studies have been published to verify the beneficial properties of consuming or using the Dhub as described above.

Lizard usage in gastronomy

A COMMON HUMAN WORLD-WIDE BEHAVIOUR

The use of lizards as food for humans can be traced from the middle Pleistocene in Asia (Java) (Auffenberg 1988; references in Monchot et al. 2014) until today (Buffrénil and Hémery 2007). Human consumption of lizards has also been reported in South America (Peru) and the pre-Columbian Neotropics (Cooke 1981) during the 'Neolithic' period, where the species consumed were *Dicrodon* sp and *Callopistes flavipunctatus* (Béarez et al. 2011). These species are still eaten today (Holmberg 1957). In the western desert of Egypt there is evidence of Uromastyx consumption in a Neolithic site (Van Neer and Uerpmann 1989). Lizards have been also hunted as food in rural areas of Spain (e.g. *Timon lepidus*, Castilla et al. 1991).

Because the consumption of a wide variety of reptile species has been an important source of protein for humans world-wide for millennia, many wild species (e.g. terrapins. snakes, lizards, crocodiles and iguanas) are now farmed and the consumption and trade of their meat and other edible products has increased in some areas of the world (Magnino et al. 2009).

EATING THE DHUB IN THE ARAB CULTURE AND RELIGION

Although lizards have been eaten in the past in many different countries, the consumption of lizards is a long-established practice in Arab countries. In the Arabian Peninsula, the spiny-tailed lizard (*Uromastyx aegyptia*) was one of the sources of subsistence for the inland inhabitants, who also consumed other desert animals (e.g. the monitor lizard, Ethiopian hedgehog, hares, gazelle) as important nutritional supplements to their diet. The Arabic tradition associates this dietary custom with nomadic Bedouins. However, ethnographic studies in Central Oman (Elmahi 2002) as well as the discovery of bones in urban zones of pre-Islamic Saudi show that city dwellers in the region also consumed the Dhub (Monchot et al. 2014).

The first zooarchaeological confirmation of the consumption of lizards by the medieval Arab population of Central Arabia has recently been described (Monchot et al. 2014). The authors have found a total of 145 skeletal remains (skull trunk, forelimb and hindlimb) belonging to the Dhub (*Uromastyx aegyptia*) in various archaeological layers of the Late Pre-Islamic/Early Islamic site of al-Yamâma, Saudi Arabia. The presence of lizard bones mixed with other bones considered mostly as food-waste, and the identification of a cut mark on the tibia of the lizards made by a cutting tool, suggest an anthropogenic origin of the material (Monchot et al. 2014).

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The Bedouins spending most of the time in the desert have a tradition of capturing Dhubs

EATING DHUBS IN THE ARAB CULTURE AND RELIGION

The practice of eating the Dhub is documented in historical sources, as well as in the *Hadiths* of the Prophet Muhammad (PBUH), i.e. the reports of his deeds and sayings. Travellers' reports from the late 19th and early 20th centuries and more recent ethnographic studies likewise report this practice (Monchot et al. 2014).

On the eve of Islam, lizards were a constituent part of the diet of the Arabian population, being mentioned in several *Hadiths*. A recurrent episode in this written tradition is that of the Prophet Muhammad refusing to consume it personally but not condemning it (Lecomte 1965: 350; Bettini, 1998: 80). Contrary to what the 19th-century traveller Burckhardt said, lizard was not eaten "in defiance of the laws of the prophet" (Burckhardt 1822: 664) since it was not considered as *harâm* (forbidden). In the mid-11th century AD, on his way back from Mecca to Persia, when crossing central Arabia, the Persian traveller Nasir-i Khusraw wrote that as soon as his fellow travellers caught sight of a lizard, they seized it, killed it and ate it (Schefer 1881: 219). The Egyptian historian al-Nuwayrî (1279-1332) mentions the consumption of lizards among the tribe of Banû Tamîm (Shams al-Dîn 2004: 167), recalling the fact that it was tolerated by Islamic law but that other Arabs took this tribe for fools because of this habit (Monchot et al. 2014).

Because Islamic scholars have two views regarding Dhub consumption, either of it being Haram (forbidden) or Halal (permitted), hunting may affect the environment or can cause the extinction of local Dhub populations. The law could then forbid eating them to preserve biodiversity and the environment in Arab countries.

ABOUT THE DHUB MEAT AND EGGS

Dhub meat is considered a delicacy irrespective of their putative medicinal properties. It is also believed that is rich in proteins and amino acids, which is true for all meat. Dhubs are not only consumed by Bedouins in the desert but also by researchers from the Occident: "I have also eaten a piece of the lizard tail roasted and found it good" (Dickson 1965).

The Dhub meat is soft like chicken or fish with a taste of chicken. The nicest part of the body is the tail. The tradition of consuming Dhubs has been so common and widespread in the Middle East that scientist have examined the nutritional quality and cholesterol content of Dhub meat and suggested the need to evaluate the suitability of their meat for human consumption (Abu-Tarboush et al. 1996a, b). There are also farms specialised in Dhub production (e.g., http:// www.youtube.com/watch?V= RVZhEWOtHbs).

The Dhub eggs are also highly sought after, which is the reason why hunters in Arab countries prefer to capture females in spring. However, eggs to be eaten have to be small. Long, large oviductal eggs are rejected because it is believed that a little Dhub embryo is inside and Arabs reject consuming such eggs. There is scientific evidence that no little embryo is inside the oviductal eggs of the female (Vickaryous and McLean 2011). The embryo does not start development inside the females but afterwards during incubation in the soil. Dhub eggs found buried in the soil are not consumed by Arabs, however turtle eggs are collected to make soup.

If Dhubs are killed by a car they can not be eaten because they are not killed in the Islamic way. The butchery process has to follow Islamic principles. Once captured, lizards are usually slaughtered by severing the head and the limbs, an action likely to cause a cut mark on the tibia. Then the lizard is skinned and cut into small parts for cooking. The eggs can be cooked with the other parts of the lizard or eaten raw (Monchot et al. 2014).

In the past and continuing into recent times, many dishes of different kinds are prepared with Dhub meat eggs, either fried, in soup, or served with rise or salad. European travellers, who crossed the Arabian Peninsula in the past, also captured lizards to use the scaly skin to preserve butter, water or to make tobacco purses (Monchot et al. 2014).

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Developed eggs inside the oviduct of a Dhub female ready to be laid. The content of the eggs at these stages is yolk

Risks associated with the consumption of reptiles, both farmed and wild meat and eggs include infections caused by bacteria (*Salmonella* spp., *Vibrio* spp.), parasites (e.g. *Spirometra, Trichinella, Gnathostoma*), as well as intoxications by biotoxins (Magnino et al. 2009). For crocodiles, Salmonella spp. constitutes a significant public health risk due to the high intestinal carrier rate which is reflected in an equally high contamination rate in the fresh and frozen meat.

There is a lack of information about the presence of salmonella species in meat from other edible reptilians. Parasitic protozoa in reptiles represent a negligible risk for public health compared to parasitic metazoans, of which trichinellosis, pentastomiasis, gnathostomiasis and sparganosis can be acquired through consumption of contaminated reptile meat from crocodile, monitor lizard, turtle and snake. Freezing treatment inactivates *Spirometra* and *Trichinella* in crocodile meat, but the effectiveness of freezing of other reptilian meat is unknown (Magnino et al. 2009).

Biotoxins that accumulate in the flesh of some reptiles can cause mortality in humans. However, infections by fungi and viruses that occur in reptiles have not been linked to human health risk through the contamination of their meat (Magnino et al. 2009).

Lizard declines require action

Recent studies have documented huge declines in lizard populations in many parts of the world. This has been linked to a variety of threats including habitat loss, degradation and fragmentation; the pet trade; invasive species; pollution; diseases; climate change and hunting by humans (Böhm et al. 2013, Cox and Temple 2009, Gibbons et al. 2000). A recent survey on the status of reptiles in the world has shown that nearly one in five reptilian species are threatened with extinction and one in five classified as Data Deficient (Böhm et al. 2013). Such a rapid worldwide decline of reptiles has raised concerns about their conservation and the urgent need for action (Gibbons et al. 2000).

Important note about this book

Chapter VII in this book has been conceived to contribute toward the Qatar national databases of wildlife and presents the first distribution maps for the Qatari lizards and is an updated list of the lizards that are currently present in Qatar. The maps, the names of the species and the information on species richness have been supervised by a team of international expert scientists, and the results have been published in three international journals to make biodiversity knowledge in Qatar available to the Gulf Region and to the international community (Castilla et al. 2013, Valdeón et al. 2013, Valdeón et al. 2014, Cogălniceanu et al. 2014). However, it is very important to inform the readers of this book that all distribution maps presented are only preliminary. In the Qatar Peninsula there are 149 grid squares of 10x10 km, but fewer than half (48%, of the squares, n=72) were possible to survey to make the current maps. Also, many of the squares have been visited only once. Consequently, although these maps are the first ones available for Qatar, they are still incomplete. It is quite likely that all lizard species are present in a larger number of squares than those indicated in the preliminary maps shown in this book.

II
THE STATE OF QATAR AND ITS ENVIRONMENT

The State of Qatar and its Environment

Country size and population

The state of Qatar is a peninsula with an area of 11,651 km2 that lies between 24-270N and 50-520E. The peninsula projects 186 km north from Saudi Arabia, varies in width between 55 and 90 km, and have a coastline length of about 700 km (Qatar Statistics Authority 2013).

Location of Qatar within the Arabian Peninsula (Qatar Statistics Authority 2013)

The vast area of the Qatar country still lies vacant with bare soil, sand, sand dunes and scanty vegetation. Based on the census of 2010, the barren vacant land represents 91% of the Qatar´s surface, while the rest includes areas under residential use (3%), industrial and commercial use (3%) and farms and cultivated areas (3%) (Qatar Statistics Authority 2013). Livestock farming constitute a very important activity in the country and Qatar has the highest density of camels (*Camelus dromedarius)* in the Middle East and the third highest amongst surveyed North African countries (Richer, 2008). Pastural breeding also includes domestic goats (*Capra aegagrus hircus*) and sheep (*Ovis aries*).

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Raising pastoral animals is a very important activity in Qatar

Human population in Qatar has been increasing rapidly throughout the last decades, reaching currently 1.8 million inhabitants mainly concentrated (80%) in the capital of the country (Doha) (Qatar Statistics Authority 2013). There are two groups of main cities, some belong to the history of the country and have grown according to the infrastructure and the socioeconomic development. Others are industrial cities developed by the government considering special needs of industries located in specific areas.

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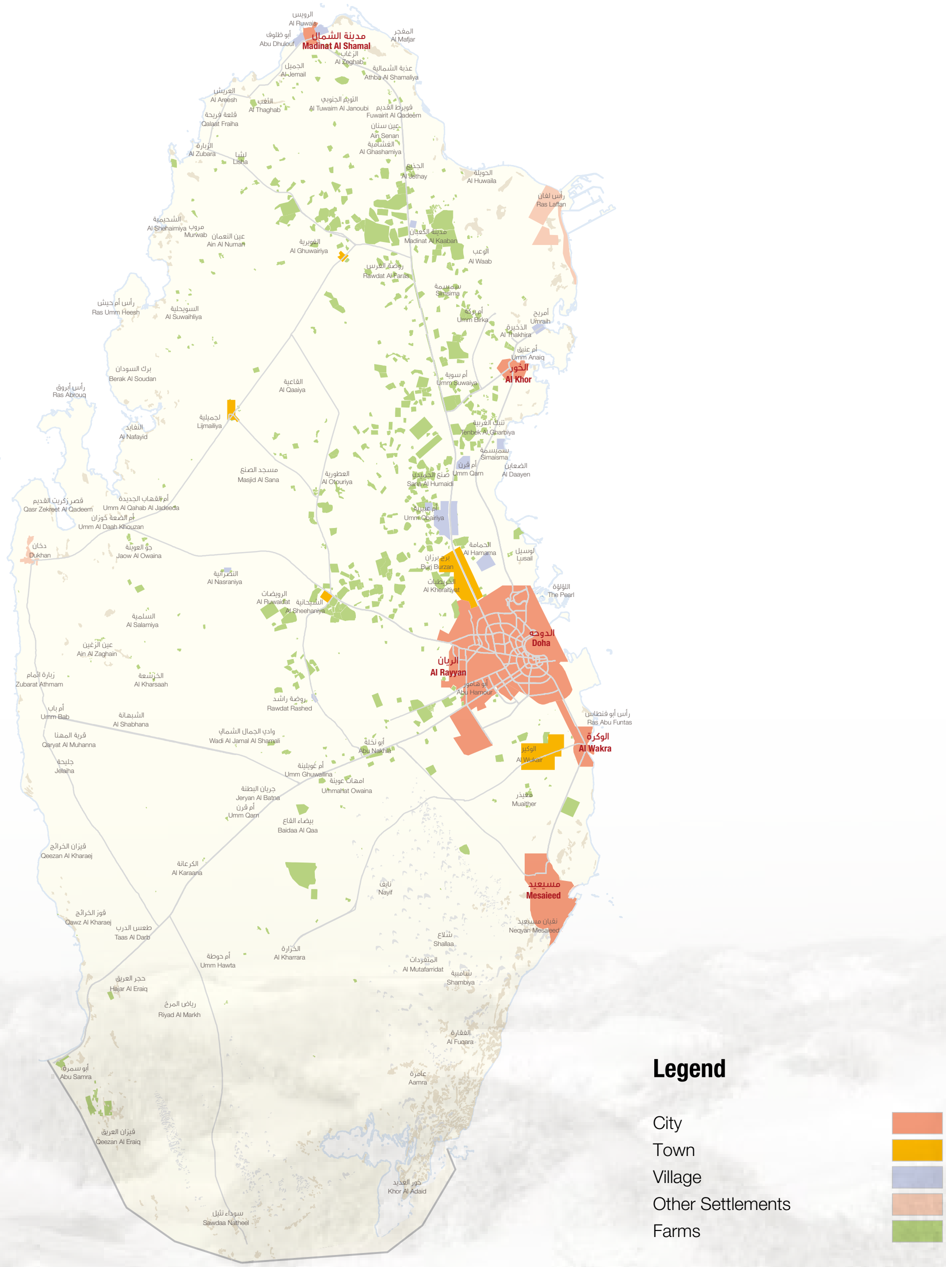
View of West Bay in Doha city, capital of Qatar

Doha is the main and biggest city which now includes Al Rayyan. Al Wakra is another old town reflecting traditional architecture, and it has an important harbour for fishing boats. Medinat Al Shamal is in the extreme north of the country and is important for fishing villages. Among the industrial cities, Dukhan and Mesaieed are the oldest ones whereas Ras Laffan is more recent and the Al Khor town houses their employees.



Map showing the most important settlements and roads in Qatar

The economic growth of Qatar is closely related to ongoing increases of hydrocarbon extraction, since Qatar lies in a strategic location with major petroleum and gas deposits (Qatar Statistics Authority 2013). In Qatar there are 7790 km of roads (0.67 km road/km2) of which 90% are paved. There are also 571 cars per 1,000 people (2002 estimation) (Hutchinson Encyclopedia 2011).

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View of Doha town in an emblematic zone of Corniche

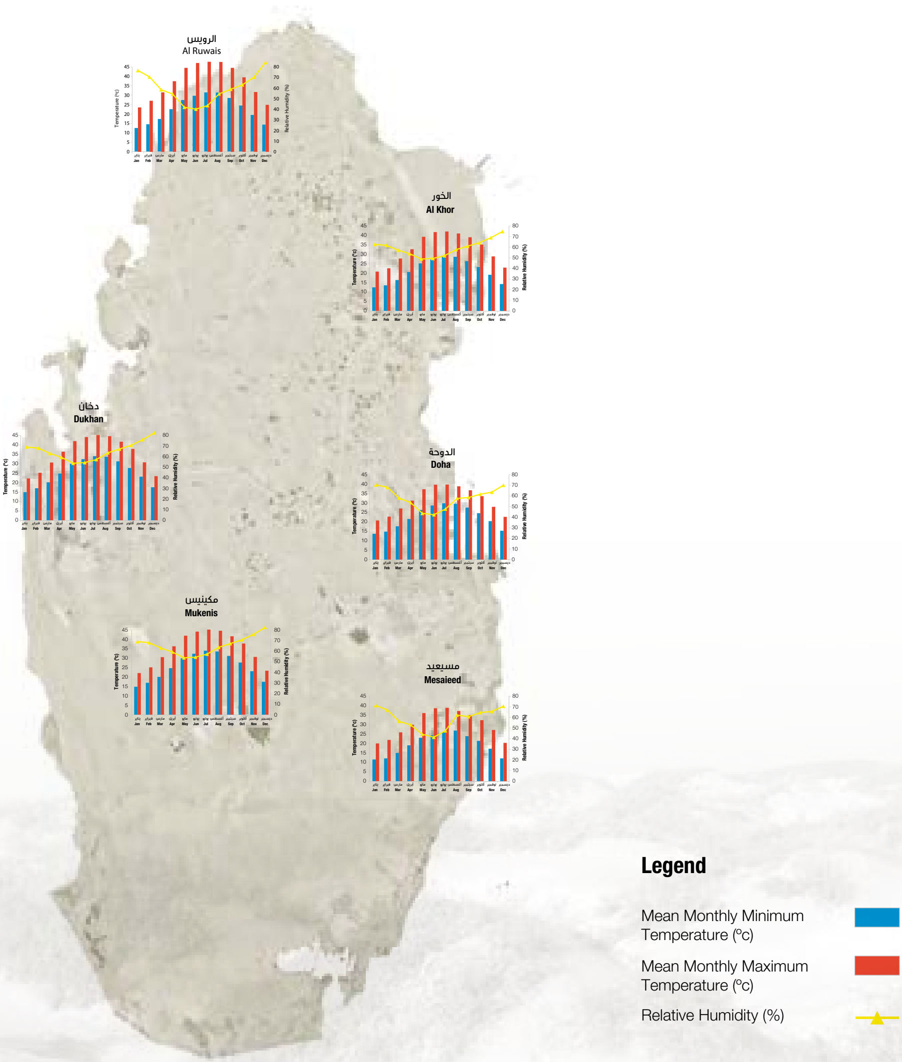
Elevation

Qatar overall has a flat rocky surface, rising to 103 metres in the highest point located in the south of Qatar, in Tuwayyir Al Hamir (Latitude: 24.716667/Longitude: 51.15). About 60% of the land surface area of Qatar falls under 10 meters above the mean sea level. There are occasional low hills seen in the Dukhan area in the west of Qatar and in the northeast near Jabal Fuwairit, which are rocky limestone ridges having marked depressions with considerable Aeolian sand accumulations. Shifting sand dunes ranging up to 40 meters in height can be seen scattered over the south-eastern part of Qatar and some along the north eastern coast near Ras Laffan. The northern part is relatively lower in height, gradually increasing towards the west and south-west.

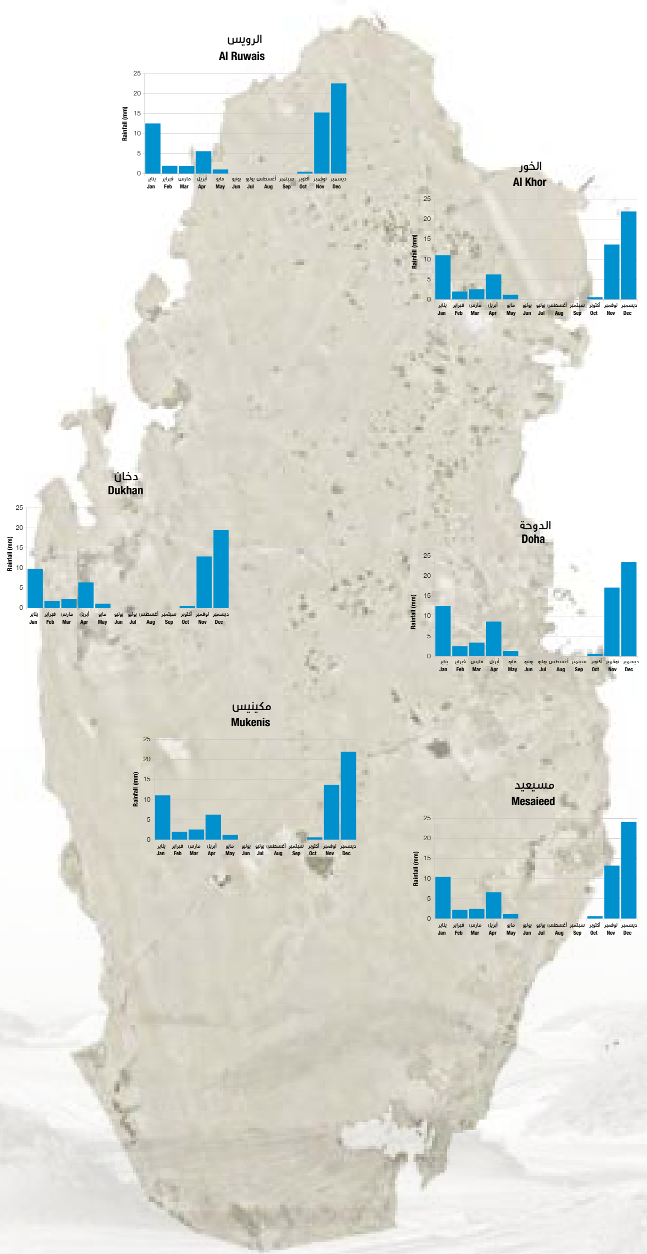
Climatic conditions

Qatar's climate is characterized by hot and humid summer and semidry short winter with scanty rainfalls mainly during winter. The winter months are more humid, whereas June is the driest month of the year. The highest temperatures are experienced during June to August, and temperatures are lowest during December and January. Considering the period between 2002 and 2011 and data from the meteorological station at Doha airport, the average annual mean temperature in Qatar is 29°C (min-max: 15°C in January and 43°C in July). The average annual rainfall is 45 mm (min-max: 0 from June to September and 19 mm in December). The average annual mean humidity is 62% (min-max: 47% in May and 75% in December and January) (Qatar Statistics Authority 2013).

The northern areas of the country experience more rainfall and decreases to the south of the country. However, there is not much variation in the distribution of temperature, humidity or rainfall from one zone to another in Qatar. The climatic maps are based on the data available in six meteorological stations located in Qatar (Qatar Statistics Authority 2013).



Map of temperature and relative humidity in different zones of Qatar. The blue columns indicate mean monthly minimum temperatures and the red columns show the mean monthly maximum temperatures (both in degrees centigrade, °C). The yellow line shows the relative humidity (in percentages, %)

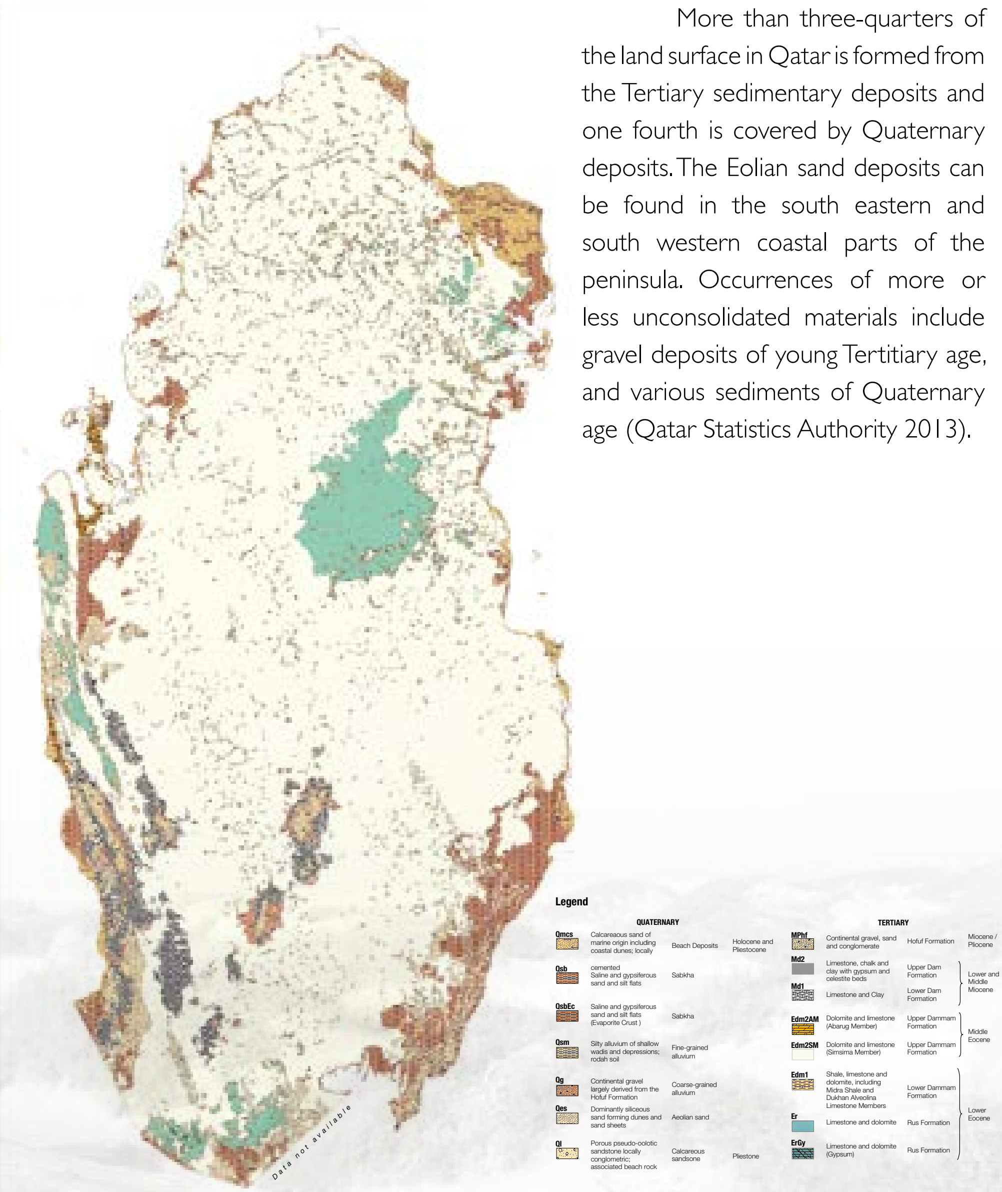


Map of precipitation in different zones of Qatar. The blue columns indicate mean monthly rainfall (in millimetres, mm)

Geology

The largest part of Qatars flat surface belongs to the Lower to Middle Eocene beds (Upper Dammam formation) consisting of a thick complex of terrestrial and marine deposits. The oldest rocks exposed are the limestone of the Rus Formation of the Lower Eocene age, and the most widely spread outcrops are the dolomites and the crystalline chalky limestone of the Upper Dammam formation of Middle Eocene age (Qatar Statistics Authority 2013).

More than three-quarters of the land surface in Qatar is formed from the Tertiary sedimentary deposits and one fourth is covered by Quaternary deposits. The Eolian sand deposits can be found in the south eastern and south western coastal parts of the peninsula. Occurrences of more or less unconsolidated materials include gravel deposits of young Tertitiary age, and various sediments of Quaternary age (Qatar Statistics Authority 2013).

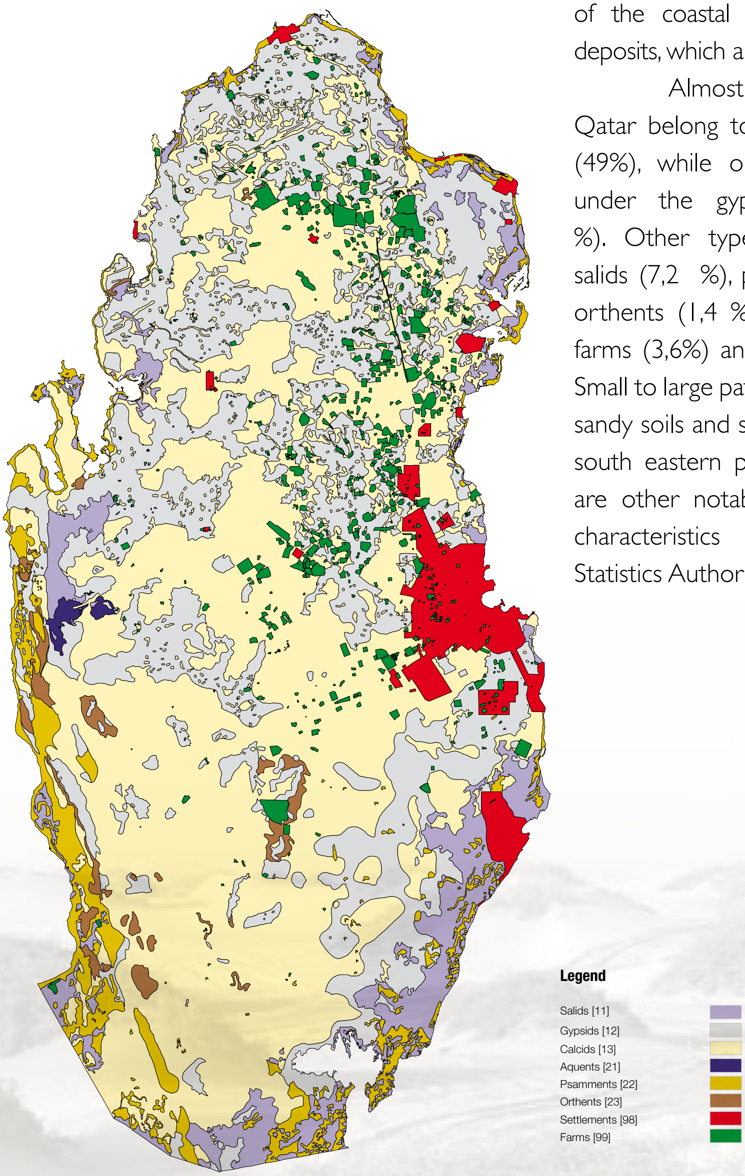


Geological map of Qatar. See legend for interpretation

Soil

The soils in Qatar are primarily aridisols characterized by water deficiency and very poor concentration of organic matter. These are primarily rocky soils and are very shallow in formation (10-30 cm deep). Overall the country is covered by calcareous sandy loam to loam soils whereas small to large patches of rocky limestone outcrops are found scattered over the south-western part of the country (Qatar Statistics Authority 2013). There are some depressions (Rodah soils) found scattered mainly in the northern part of the country which are considered to be fertile lands. The depth of soil in some zones ranges from 30 to 150 cm. Some of the coastal areas have Sabkha deposits, which are soils highly saline.

Almost half of the soils in Qatar belong to the calcids group (49%), while one third area falls under the gypsids group (29,3 %). Other type of soils include salids (7,2 %), psamments (5,7 %), orthents (1,4 %), aquents (0,3 %), farms (3,6%) and settlements (4%). Small to large patches of wind blown sandy soils and sand dunes over the south eastern part of the country are other notable features of soil characteristics in Qatar (Qatar Statistics Authority 2013).



Soil map of Qatar. See legend for interpretation

Vegetation

There are no forests in Qatar and vegetation coverage is scarce with some Acacia trees, bushes and grasses which many are ephemeral sporadic species that appears after the rain (Batanouny 1981, Bari 2012a, b). Rodah (colluvium depressions) harbour denser vegetation, and trees and shrubs are mainly concentrated in these areas. The Rodah are mainly found spread over the northern part, most of those areas have been converted into farming. Date palms and exotic vegetation is concentrated in farms and gardens. Other notable features of vegetation in Qatar are the mangroves found in the coastal areas of Ras Laffan, Al Khor and Al Wakra.

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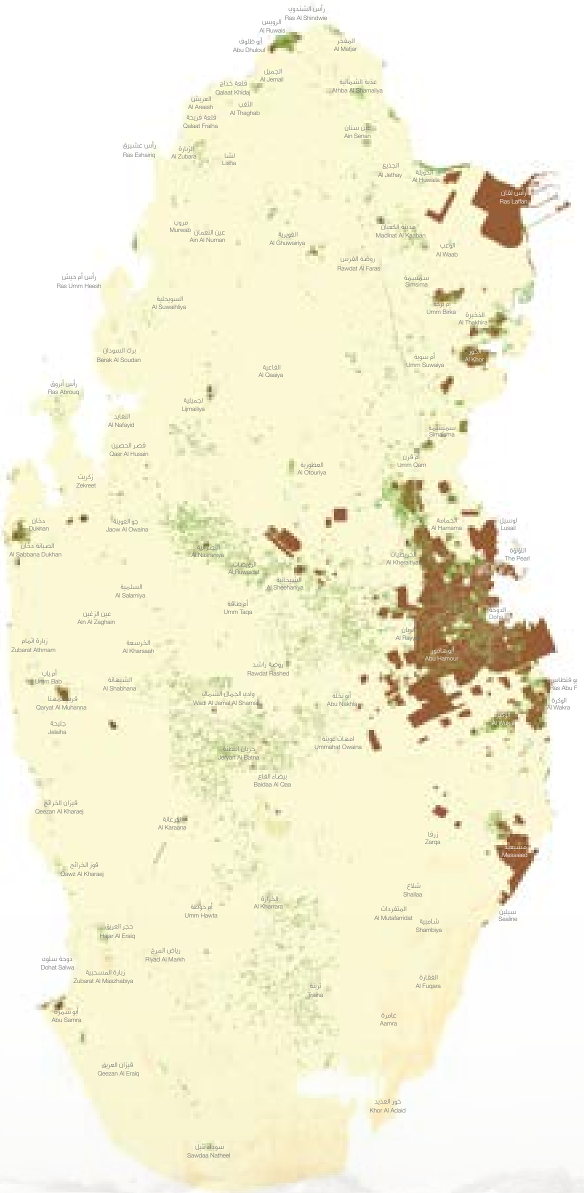
View of mangroves in Al Khor

There are two important plant communities in Qatar, the non-halophytic community include *Ziziphus nummularia*, mainly found in Rodah; the *Acacia tortillis*, is found widely spread in Qatar except in Sabkhas and dunes. *Cymbopogon parkeri* is an aromatic perennial grass that occurs in depressions; *Panicum turgidum* is a grass primarily found in the southern part of the country, and other common plants such as *Francoeuria crispa, Tetraena qatarense, Cornulacea monacantha, Hammada elegans, Pennistum divisum, Rhanterium epapposum and Chrysopogon aucheri.*

The halophytic plant communities include *Avicennia marina, Arthrocnrmum glaucum, Halocnemum strobiolaceum, Halopeplis perpoliata, Suaeda vermiculata, Limonium axillare, Aeluropus lagopoides, Halopyrum mucronatum and Sporobolus arabicus* (Batanouny 1981, Bari 2012a,b).



Legend

- Mangrove
- Scrub Area
- Wooded Area
- Cultivated Area
- Plantation Area
- Sand Dune Area
- Settlements

Vegetation map of Qatar. See legend for interpretation

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Nowadays the ostriches are not free in Ras Brouq

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Film city, located in the north of Zekreet where the office of the General Directorate of Natural Reserves is settled

Protected areas

Protected areas are zones in which human occupation or at least the exploitation of resources is limited, following the International Union for Conservation of Nature (IUCN) (Dudley 2008). Protected areas receive special protection because of their recognised natural, ecological and/or cultural values; and the level of protection depends on the laws and regulations of each country and the international organisations involved. There are over 161,000 protected areas in the world (as of October 2010) with more added daily, representing between 10 and 15 percent of the world's land surface area (Soutullo 2010, Mora and Sale 2011).

Protected areas are essential for biodiversity conservation. They are the cornerstones of virtually all national and international conservation strategies. They are areas set aside to maintain functioning natural ecosystems, to act as refugia for species and to maintain ecological processes that cannot survive in most intensely managed landscapes and seascapes. Protected areas act as benchmarks against which we understand human interactions with the natural world. Today, protected areas are often the only hope we have of stopping many threatened or endangered species from becoming extinct (Dudley 2008).

There are eleven protected areas in the Qatar terrestrial territory with a total surface of 2743 Km2 (24%). This percentage is higher than in most countries of the world (http://upload.wikimedia.org/wikipedia/commons/2/2f/Protected_areas_by_ percentage_per_country.png). The Qatar protected areas include parks and landscapes across many ecosystems and attempts to protect a broad range of Qatar´s wild species. These areas are also thought to serve as useful educational grounds to increase public awareness on conservation and environmental issues.

Qatar´s protected areas still require an administrative plan and management along multiple criteria including: a) coverage of diverse species of flora and fauna, b) coverage of all major biomes, c) assessment of capacity and regulation for hunting, d) promotion of safe tourism and public awareness, e) reintroduction of animals, f) nominations for international recognition (e.g., UNESCO).

Green landscape in the Al Rafa Protected Area of Qatar

Map showing the protected areas in Qatar

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The conservation and management of the Protected Areas in Qatar require intense efforts and dedication from General Directorate of Natural Reserves (GDNR), the Ministry of Environment (MOE) and other collaborative parties

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Meetings and planning is very important before starting field work

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Oryx and Gazelles are some of the treasures in the Protected Areas

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Mangroves in the Protected Area of Al Thakhira (North East Qatar)

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Truffles grow big in the Protected Areas

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During the rainy season many areas are fully green in the Protected Areas

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Old natural date palms can be found in Protected Areas

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Aerial view of Film City in Al Reem (UNESCO MAB Biosphere Reserve)

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The Hubara (*Chlamydotis macqueenii*) live and reproduce in the Protected Areas of Qatar

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Experts from the Natural Reserves-Protected Areas working with scientist in Al Maszhabiya (South West Qatar)

III
METHODS

METHODS

Field surveys

The methods used to compile an inventory of the lizard species occurring in Qatar consisted of active searching in the field during the day and night. Most types of habitats were inventoried and special focus was given to searching under natural cover (e.g. rock-flipping) and artificial (i.e. litter) cover that often provides shelter to reptiles. Occasionally pitfall traps and artificial trap covers (i.e. cardboard) were used to capture and identify lizard species.

Lizard biodiversity has also been explored on some islands using the same methods. Halul Island (25.67N, 52.40E) is situated in the north-east of Qatar, 81.5 km from the nearest coast in Al-Khor. Al Aaliya Island (25.41N, 51.56E) is situated 2.5 km from the eastern coast near Doha city. Al Saflia Island (25.34N, 51.58E) is also in the eastern coast at a distance of 3.1 km from Doha. Al Aaliya and Al Saflia islands are separated by 5.5 km. We have also explored the islands situated in the north of Qatar near Al Ruwais.

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Surveying biodiversity requires large 4x4 cars to move in the desert while transporting equipment, materials, traps, personnel and animals


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Dhubs captured in Ras Laffan and transported temporarily for research to the labs in Qatar Foundation, Doha


53

Boats are needed to reach the islands near the mainland

54

Aerial views and photographs from the helicopter are essential to better understand landscape desert ecology.

55

Helicopters are also needed to reach the islands which are far from the Qatar mainland, like Halul island, which is situated at approximately 100 km from Doha

56

57

Before conducting biodiversity work in Qatar a lot of meetings, planning and permits are needed from the government and gas companies (Qatar Petroleum and Ras Laffan in the photographs)

58

Teaching classroom to get the right information about safety and security and make possible the visit to Halul island to conduct scientific research

59

Biodiversity surveys were done during the day

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Biodiversity surveys were done during the night

61

62

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64

We have inventoried most types of habitats in the Qatari desert and in man-made landscapes

65

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67

Field surveys require the participation of many people, and the staff in Qatar Petroleum and Ras Laffan have provided great help

Learning from local farmers and Bedouins

68

69

Farmers and Bedouins in the desert have extensive knowledge about nature, animals and plants and they are very helpful sharing a lot of information with the scientists. Qatari students help scientists with the translations and the field work

70

Qatari nationals help the members of the international biodiversity team to learn some local customs and the most basic words in Arabic to interact with locals in Qatar

Lizard tracks

71

When lizards are not visible we can still detect their presence by observing their tracks on the sand

72

73

Tracks of the Dhub (*Uromastyx aegyptia*)

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75

Tracks of the skink (*Scincus mitranus*)

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77


When lizards can not be seen directly, their presence can be detected by their excrement on the soil. However, excrements are eaten often by insects and also decompose and can therefore disappear. Fresh and dry excrements of the Dhub (Uromastyx aegyptia) are shown here

Lizard trapping and sampling

78


79


Pitfall traps used to capture skinks in the dunes

80

Cardboard fences used to try capturing the legless worm lizard

81

Capturing lizards in Ras Laffan to conduct scientific research

82

Students at Weill Cornell Medical College learning how to use a noose to capture lizards

83

Scientist using a noose in the field to capture lizards hidden under a bush. The lizard, *Acanthodactylus schmidti,* before being captured with the noose

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86


Dead lizards, either fresh, dry or parts of them are very useful for scientific research and are also collected during field surveys

87

By surveying carcases of dead animals we can find lizards that are either hidden or eating insects

Lizard measurements

88

Experts of the Ministry of the Environment and their children measuring lizards in the Qatar desert

89

Young students enjoy a lot helping scientists

90

The bags used to weigh the lizards have to be weighed to discount its mass and get an accurate body mass measurement of the lizards

91

Big lizards with sharp teeth and nails are covered to protect scientists during the measurements

92

The careful examination of the animals in the field is essential before they are released in the same place as they were captured

93

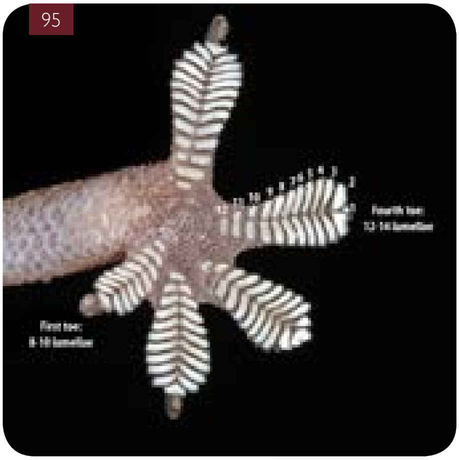
Digital calliper used to conduct morphological measurements of the lizards

94

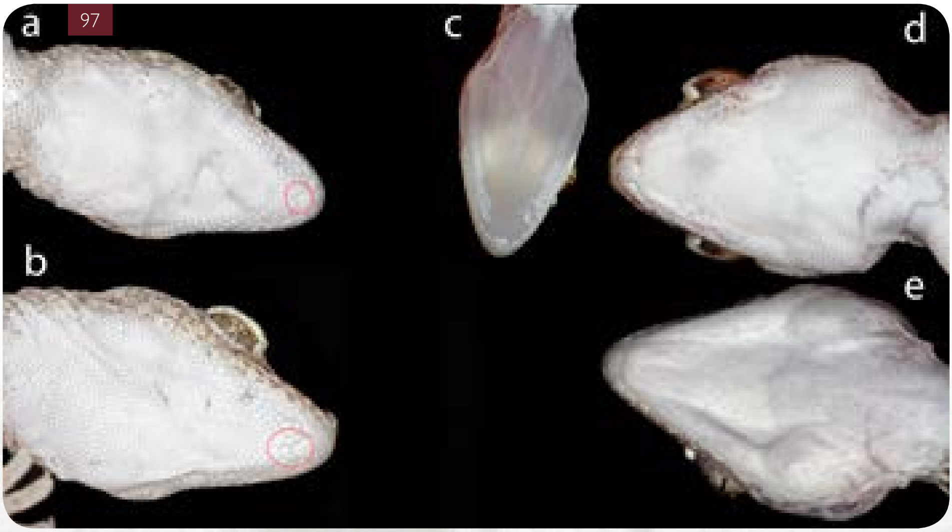
Bite forces were measured in Qatari Dhubs and we discovered that males and females with similar body size also have similar bite forces. The maximal bite forces recorded in the Dhub is of 141 Newtons (Herrel et al. 2014)

Lizard classification and scientific names

The lizard species were identified based on morphological traits described in Arnold (1986) and Leviton et al. (1992). The most current changes in the nomenclature of the species were according to Fujita and Papenfuss (2011), Moravec et al. (2006), Pyron et al. (2013) and Bauer et al. (2013).



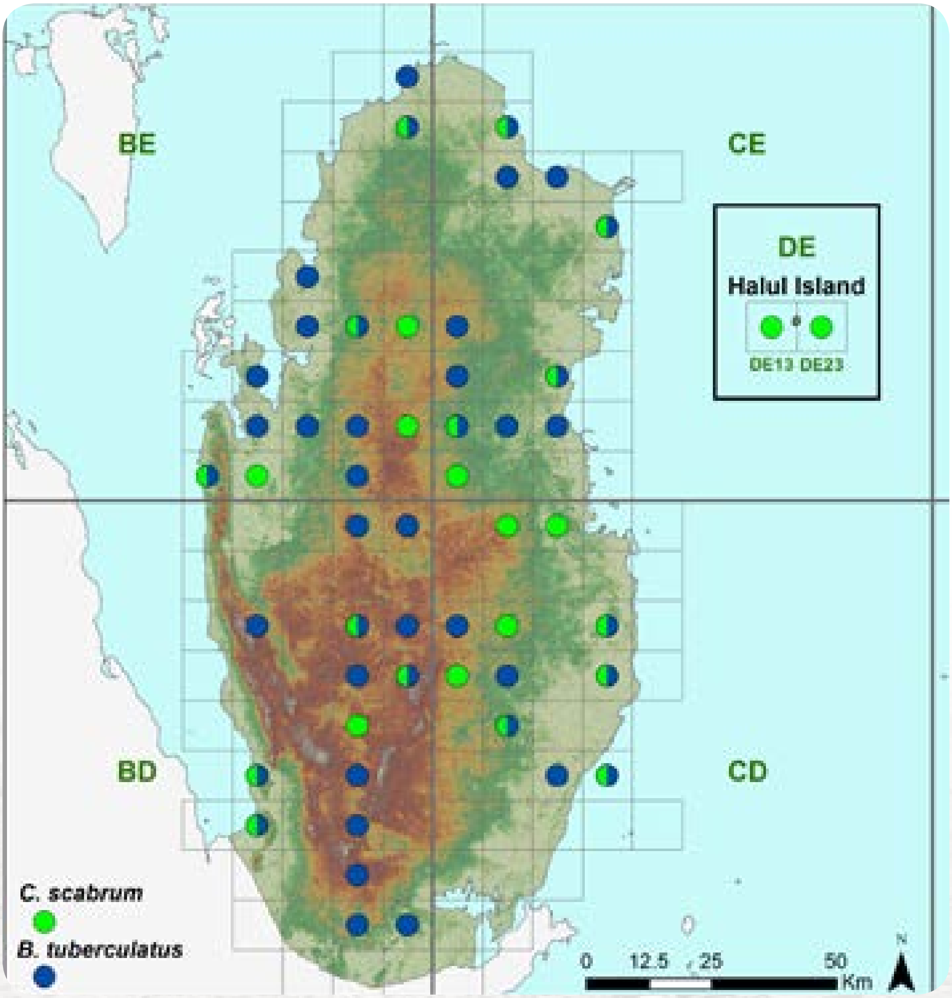
The number of lamellae under the fingers of some nocturnal geckos are important to distinguish between taxa



Lizard scales are very important characters to recognize species and distinguish between them. Gular view of the lizard *Pseudoceramodactylus khobarensis* showing (a) one pair and (b) two pairs of postmental scales. The gular area of other closely related gecko species living in Qatar: (c) *Stenodactylus arabicus*, (d) *Stenodactylus slevini* and (e) *Stenodactylus doriae*

Creation of novel distribution maps for lizards in Qatar

Biodiversity atlases of animals and plants are very popular in many countries and constitute an essential tool for species management and regional planning. Specific coordinate systems and spatial resolutions are used depending on the surface area covered in an atlas. Some examples can be seen in previous distribution maps where the authors used 1° grid (ca. 100 x 110 Km) for reptiles (Sindaco and Jeremcenko 2008) or 30° grid (ca. 50 x 55 Km) for birds (Jennings 2010). Both examples cover a wide area and the spatial resolution is fitted to each boundary size. The 10 x 10 Km resolution is considered standard in atlases of smaller geographic areas like Qatar (Dobbyn 1994, Pleguezuelos et al. 2002, Jennings 2010, Bonelli et al. 2011).



Map showing the distribution of two lizard species in Qatar using a 10 x 10 km grid

We have designed useful and objective maps to simplify the visualization of the data obtained from our biodiversity surveys, and which can be useful for other species of the terrestrial and marine environment in Qatar (Valdeón et al. 2013). To identify the distribution of lizards and map the biodiversity in Qatar, it is important to assign the names of the squares in the Qatari grid. We have developed a Qatar National Biodiversity Grid (QNBG) employing a method based on the UTM projected coordinate system where each square is codified in alpha-numerical nomenclature based on the Qatar National Datum (QND95) coordinates expressed in meters. On the map, the position of the Qatar National Convention Centre (QNCC) located in the square CD29, is shown (Valdeón et al. 2013).

We have provided a two letter name to each 100 x 100 Km square, where the first letter corresponds to the X axis and the second letter to the Y axis. An "A" is assigned when the coordinate is between 0 and 99999, "B" when it is between 100000 and 199999, "C" when it is between 200000 and 299999, and so on. The 10 x 10 Km squares are named with the letters of the 100 x 100 Km squares in which the specific grid is located, and two digits from 0 to 9, which are the second digit of the X coordinate and the second digit of the Y coordinate (Valdeón et al. 2013).

Since the squares are based on standardized Qatar National Datum (QND95) coordinates, it is possible to know in which grid square we are working by using a handheld GPS previously configured with QND95 datum. In addition, when GPS data are obtained in other datum, they can be converted to the QND95 with a coordinate converter to integrate all data into a biodiversity atlas using the same coordinate system (Valdeón et al. 2013). Information from different sources can be compiled to use for biodiversity mapping and habitat management if these data have the same spatial reference. It is also possible to estimate "hot spots" of high conservation value for biodiversity as well as archaeological and geological features by using GIS tools of this nature (Valdeón et al. 2013).

98

Collecting data with a handheld GPS previously configured with QND95 datum in collaboration with future Qatari scientists from Qatar Foundation

99

High accuracy GPS (Trimble Real Time Kinetic RTK8) property of Qatar Foundation used for more detailed geographic positioning

100

The collection of GPS coordinates is collated with additional data on soil and vegetation characteristics

The geographic location of each lizard in Qatar was taken using a Global Positioning System (GPS) device. We used GPS devices of different types or smart phones depending on the user preferences, but all had an accuracy of 3 to 6 meters distance. The output of the reading was often different depending on the user, but it was annotated in the note books, and afterwards transformed using a coordinate converter program on the computer.

The majority of the data included in the distribution maps shown in Chapter VI of this book come from field surveys conducted in 2012 and 2013 (Cogălniceanu et al. 2014). In addition, we have also added some records from publications by Qatar University (Anonymous 2010, Nasher et al. 2009), as well as from 41 records from local volunteers and photographers that accompanied their observations with clear photographs, GPS coordinates or grid square locations. Distribution data that did not meet those expectations was not considered when compiling the distribution maps.

To produce distribution maps for the 21 lizard species the following procedure was undertaken. The GPS geocoordinates were exported to ArcGIS 10 (ESRI) to create a shapefile, which was projected to the official reference system in the country, QND95/ Qatar National Grid (UPDA 2009). A regular grid with squares of 10 x 10 km was made following the Qatar National Grid, while adapting the traditional nomenclature of UTM (Universal Transversal Mercator) or MGRS (Military Grid Reference System) squares (NGA 2013) to the Qatar National Grid (Valdeón et al. 2013). A similar spatial resolution of 100 km2 was previously used in several national and regional herpetological atlases (see references in Cogălniceanu et al. 2014).

Distribution maps of Qatar lizards

The worldwide distribution maps shown for the lizard species have been retrieved from http://www.reptile-database.org which is maintained by Peter Uetz (database content) and Jakob Hallermann, Zoological Museum Hamburg. The region depicted in orange indicates lizard distribution and is in accordance with the Biodiversity Information Standards known as the *Taxonomic Database Working Group* (TDWG). The regions are generated automatically from data and put into a distribution field and, as such, are generated according to country boundaries. These maps are thus not the geographical position and rather highlight the species' broad distribution (Uetz and Hošek 2013). All distribution maps for the lizards in Qatar have been done by Aitor Valdeón.

About the photographs in this book

All photographs in this book have been taken in Qatar with a few exceptions. The half moon and the milky way used to introduce Chapter IX and to indicate the night environment for nocturnal species in Chapter VI were produced in the Canary islands (Spain) using the Telescopes of the Isaac Newton Group, La Palma (http://www.ing.iac.es/PR/science/).

The photos of lizards that were not seen during our surveys but which may exist in Qatar (Chapter VII) were taken outside of Qatar. An internet search was conducted to obtain the necessary photographs of the missing lizard species. Permission to use the photos was requested from the relevant authors and acknowledgments are provided in each case. As the nature of this publication is not-for-profit, only photos which were not charged for have been used. Two photos of lizards shown in Chapter I, the Gila monster and the Basilisk, have been provided, however, these species do not occur in Qatar and have been used to better illustrate the content of the chapter.

101

Members of the biodiversity team taking photographs in the field

About the chapters and references in this book

Following recommendations of scholars in Qatar, many chapters in this book are described with photographs and short texts not always being associated to scientific references. This has been done to facilitate the reading to students and locals living in rural areas.

The list of references in this book includes a general section documenting the references cited in the text and also 21 different sections including the most relevant references that we have found for each 21 lizard species separately. Because the information about lizard biodiversity in Qatar is scarce, having these references listed will help the students and researchers in the Ministry of the Environment to easily find relevant information for each lizard species that occurs in Qatar. For those lizard species that have been extensively studied internationally (e.g. *Hemidactylus flaviviridis*, with more than 400 publications, *Varanus griseous* with more than 250, and *Uromastyx aegyptia* with more than 70), we only selected some of them. We have also added scientific publications of interest on the ecology of the lizards that have been conducted by the authors of this book.

103

Searching from photographs in internet from the offices and laboratories in the College of North Atlantic, Qatar

104

When field conditions were not favourable for taking photos or when photographers were unavailable for field expeditions, photographs were taken in the laboratory

105

Qatari student co-authors of this book have helped with searching for photographs and for useful information from different Qatari institutions

IV
GENERAL BIOLOGY AND ECOLOGY OF LIZARDS

General Biology and Ecology of lizards

Lizards are a widespread group of squamate (scaled) reptiles, with more than 5,600 species occurring on all continents except for Antartica. They inhabit both natural habitats and urban zones and show great variation in body size from a few centimetres (e.g. geckos) to nearly three meters in the case of the Komodo dragon (Green and Dennis 1993). In this chapter we present information on the most basic aspects of the biology and ecology of lizards, including the importance of thermoregulation for maintenance of their activity patterns during their daily life. This chapter also provides information on their vision, how they smell and hear, the way they communicate and reproduce, the food that they eat, how much they run and which are their most important predators in Qatar.

There is a lizard in Qatar that has no legs and many people believe that it is a worm or a small snake rather than a lizard. This chapter thus explains the most important aspects of this lizard.

107

The smallest lizard in Qatar is *Pristurus rupestris*, with a maximum body length of seven centimetres. The species live in rocky substrates and is also present in Halul island

108

The largest lizard in Qatar is the monitor *Varanus griseus* which can reach a body size of more than one meter. It inhabits the desert environment in Qatar and occupies large territories

The legless worm lizard (*Diplometopon zarudnyi*) is a real lizard

Some lizards without legs are included in a group called amphisbaenians. They are the evolutionary result of a long journey of morphological and functional adaptations arising from their fossorial lifestyle. Because they are very different to the rest of lizards which live on the ground (i.e. epigeal), they have reduced vision, elongated bodies, a compact skull and a complete absence of limbs in most species (Gans 1978). They also have to solve their ecological demands with a suite of original adaptations. For example they exhibit a craniofacial angulation and expanded rostral blade related to using their heads as a digging tool (Maisano et al. 2006). The patterns of habitat selection are often just based on selecting substrates where burrowing is easy (Martín et al. 2013b). Legless lizards can sustain activity at lower body temperatures than the lizards that move on the surface, and their body temperatures closely reflect those of the substrate surrounding them. However, amphisbaenians adapt their behaviour and can maintain optimal body temperatures by moving under rocks and through areas and depths of the soil that hold appropriate environmental temperatures (Al-Johany 1999, López et al. 2002).

109

The legless worm lizard (*Diplometopon zarudnyi*) is a real lizard that was very abundant in Qatar in the past but is now very difficult to see

Underground the diversity of available prey is lower, and the legless lizards have narrow diets, often based on ants, termites or insect larvae (Webb et al. 2000, Martín et al. 2013a). Consequently, they have different feeding behaviour to handle and eat prey (López et al. 2013). They have well developed chemical senses to locate and identify suitable prey (López and Martin 1994) and avoid dangerous prey and predators (López and Martin 2001). The reproduction of these reptiles is poorly known, but they can either be oviparous or viviparous, and typically have a very low number of eggs/embryos per clutch (Andrade et al. 2006). In the case of *Diplometopon zarudnyi* that lives in Qatar, the species is oviparous.

Thermoregulation

Lizards are ideal organisms for scientists to investigate animal responses to the effects of global warming (Kareiva et al. 1993). This is because lizards are ecthoterms (cold blooded) and their body temperature depends directly on the environmental temperatures around them and on their behavioral abilities to cope with them. Thus, if a lizard needs to reach an optimal body temperature of about 35°C to 40°C in summer, they expose themselves to the sun for a while, but not for a long time, because soil temperatures and air temperatures near the substrate can be much above 50°C, which is a temperature a lizard can not sustain. Lizards therefore require cover in their habitat in which low environmental temperatures can be found, so that they can switch between sun and shade frequently. Only through those shifting movements can lizards thermoregulate efficiently and maintain their body temperature at a constant level during the periods of increased activity (Bauwens and Castilla 1996, Castilla and Bawens 1991, Castilla et al. 1999).

110

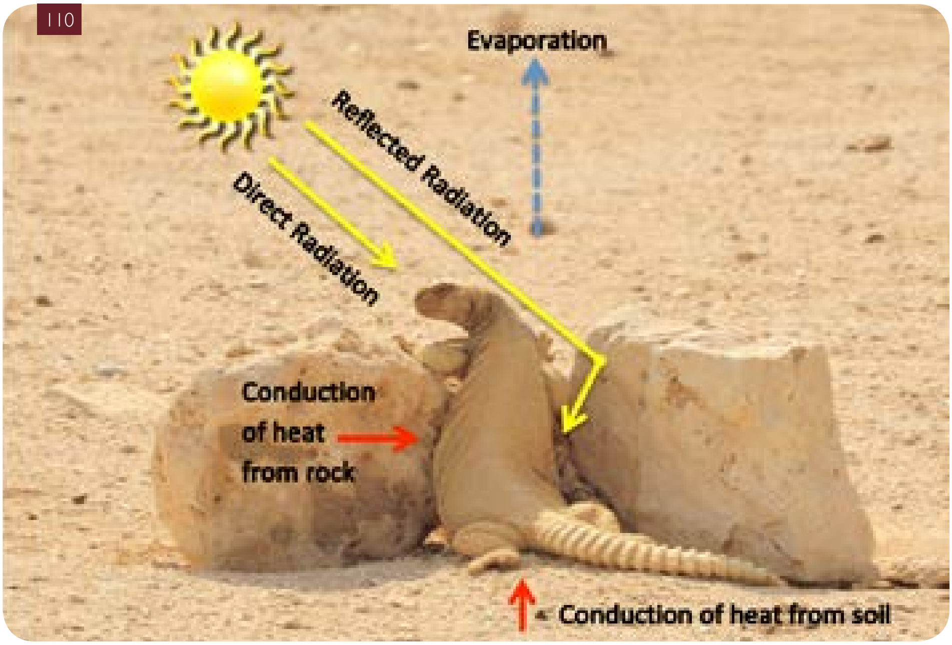


Diagram depicting different sources of temperature that lizards make use of to elevate their body temperature faster

111

Many lizards kept as pets do not eat or move when they are not provided with powerful lamps or thermal mats. Optimal body temperatures for many lizards are between 35° and 39°C

The presence of trees, bushes, rocks, burrows or artificial cover is essential for an optimal habitat where lizards can thermoregulate efficiently (Bauwens et al. 1996). When natural or artificial cover is not available, lizards are forced to modify their behavior and remain hidden for longer periods of time inside their burrows. They also approach human settlements searching for cover to avoid high temperatures. When cover of any kind is not available lizards may die from heat shock.

112

Lizards need shade to avoid overheating

113

Lizards need vegetation for cover against high temperatures and also for protection against predators

114

The soil in summer can rich over 50°C and lizards stand on their legs to reduce contact with the substrate

115

Most trees have disappeared from Qatar and lizards have to search for cover. Alternatively, they may approach areas with artificial features to find cover

Importance of burrows for thermoregulation

116

When lizards can choose, they prefer making their burrows under trees and vegetation that provides extra protection from temperatures and predators

117

When vegetation or rocks are unavailable to provide extra shade, lizards have to make much deeper burrows to be isolated from extreme temperatures, either high in summer or low in winter

A Dhub burrow under a small rock. Rocks provide extra humidity to the substrate

Digging burrows is energetically costly and lizards use holes under big rocks to make their home when these are availabler

120

We need to measure the burrow characteristics to learn about possible differences between zones in the size and depth of the burrows. These often depend on soil hardness and other characteristics of the environment

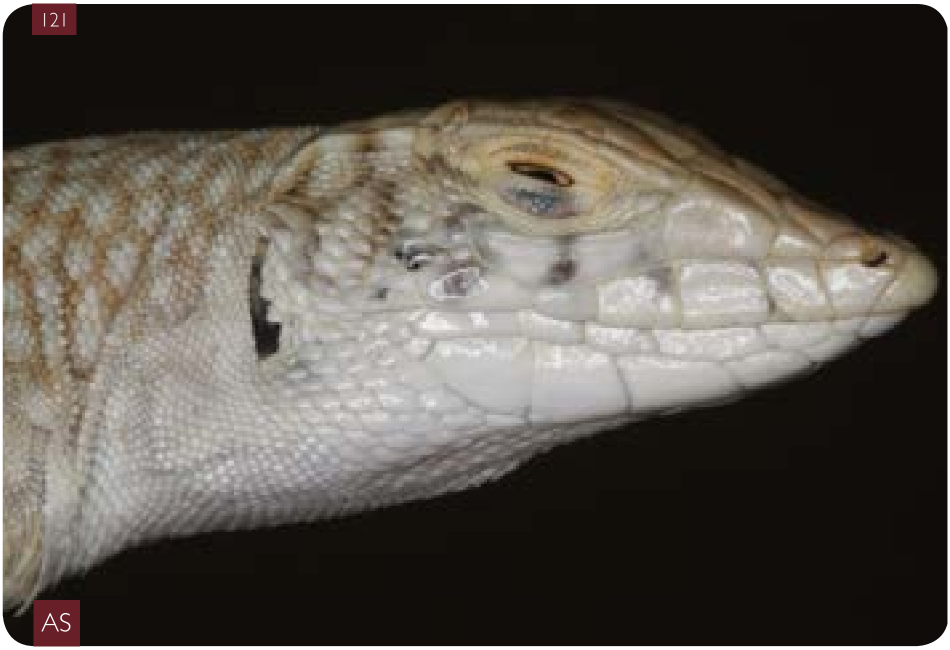
Lizard eyes and vision

Lizards have good vision and they can distinguish among colours. Because different lizard species occupy environments rich and poor in light and are active at different times of the day, the morphology of the eye varies and adapts according to the visual environment. Nocturnal geckos have large and sensitive eyes, with pupils which open wide at night to let in as much light is possible, giving it excellent vision in the dark. The pupils contract to vertical slits during the day to protect the retina (the light-sensitive part of the eye) from harsh sunlight, while the eyelids of the yellow-bellied house gecko are fused to form a transparent cover, called a spectacle, for additional protection. Any dust or debris in the eye is licked away by the gecko's extremely mobile tongue.

The pupil in lizards is usually round and relatively immobile in diurnal lizard species and is usually slit-like in nocturnal species. Some geckos have a serrated pupillary opening resembling a series of small holes when the pupil is completely closed. This specificity allows for acute vision even under dim light.

The lower lid is movable and moves upwards to close the eye. In some lizards, this lid might be transparent, allowing vision even when the lids are closed, while protecting the eye from wind and dust. Lizards also have a well developed, semi-transparent, highly mobile third eyelid which is called the 'nictitating membrane'. This membrane can close across the eye even while the eyelids remain open. In some nocturnal geckos the eyelids have fused to produce a circular, immobile and transparent dermal aperture called a spectacle. Geckos lack eyelids and they clean their eyes with their tongues.

121



AS

122

AO

The eye lid in some lizards is transparent allowing vision even when the lids are closed, while protecting the eye from wind and dust of the desert. In the photos, *Acanthodactylus schmidti* (AS) and *Acanthodactylus opheodurus* (AO)

123

CS

By chance we found one nocturnal lizard (*Cyrtopodion scabrum*) blind in the field. We should explore if there are more cases as well as the origin of this observation

124

SD

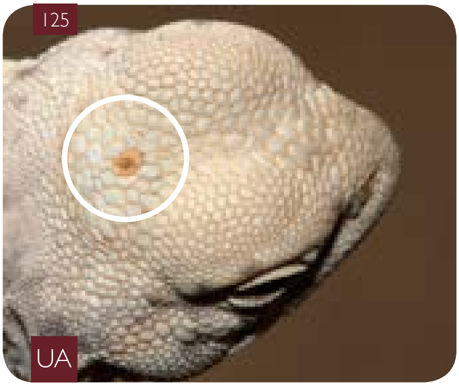
Geckos lack eyelids and they clean their eyes with their tongues. In the photo, *Stenodactylus doriae* on the Qatar san dunes


Eyes of diurnal and fossorial lizards
Varanus griseus
Uromastyx aegypita
P. arabicus
T. flavimaculatus
Acanthodactylus schmidti
A. opheodurus
Mesalina brevirostris
Mesalina adramitana
Pristurus rupestris
T. septemtaeniata
Scincus mitranus
Fossorial
Diplometopon zarudny


Eyes of nocturnal lizards
Bunopus tuberculatus
Cyrtopodion Scabrum
P. khobarensis
Hemidactylus persicus
Hemidactylus flaviviridis
Hemidactylus robustus
Stenodactylus doriae
Stenodactylus arabicus
Stendoactylus slevini

The third eye or pineal eye

Lizards also have a parietal eye also known as a third eye or pineal eye. It is visible as a spot (light-sensitive) on top of their head. This eye cannot form images but is photoreceptive and it detects UV light and heat. By detecting light and dark it allows lizards to detect the movement of predators. This eye is associated with the pineal gland, regulating circadian rhythmicity and hormone production for thermoregulation and reproduction.



The pineal eye can be seen on the head of the lizards. In the photos, *Uromastyx aegyptia* (UA), *Acanthodactylus schmidti* (AS), and *Scincus mitranus* (SM)

Smell and taste

Lizards use their tongues very differently to how we use ours. Lizards do not use their tongue for tasting the flavour of food, but as a way of finding food. The tongue is an invaluable tool for navigating their environment, and lizards smell using the tip of their tongue. They flick the tongue out of the mouth regularly to sample the chemical particles that are trapped in moisture or other parts in the environment. By doing this, a small amount of 'scent' sticks to the tongue and then it is brought into their mouths. On the roof of the mouth there is a special organ called Jacobsen's organ, which essentially functions as the nose, and helps lizards to process the scent. This form of chemical sampling allows the lizards to sense non-volatile chemicals which cannot be detected simply by using the olfactory system. This ability to sense chemicals is very useful to identify prey, recognize kin, choose mates, locate shelters and follow trails.

In addition, lizards may use their tongue to drink as well, lapping up water drops. After a lizard finishes eating, they use the tongue to lick their lips to clean them and as mentioned, to clean the eyes. The monitor lizard is the only lizard that has a forked tongue. That means that the tongue is split into two distinct tines at the tip, similar to the tongue of snakes. Sensing from both sides of the tongue allows for a better perception of the direction from where the smell is coming.

Tonge of the nocturnal lizard *Stenodactylus slevini* (SS) and the diurnal Dhub, *Uromastyx aegyptia* (UA)

130

The monitor is the only lizard that has a forked tongue that is split into two distinct tines at the tip, similar to snakes. Sensing from both sides of the tongue allows for a better perception of the direction from where the smell is coming

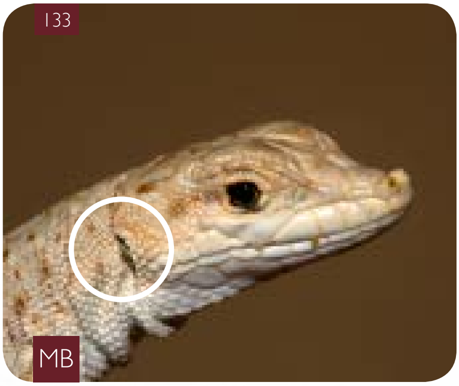
131

Lizards do not use the nose for smelling but for breathing. On the roof of the mouth there is a special organ called Jacobsen's organ, which essentially functions as the nose and helps lizards to process the scent. In this photo is the Dhub (*Uromastyx aegyptia*)

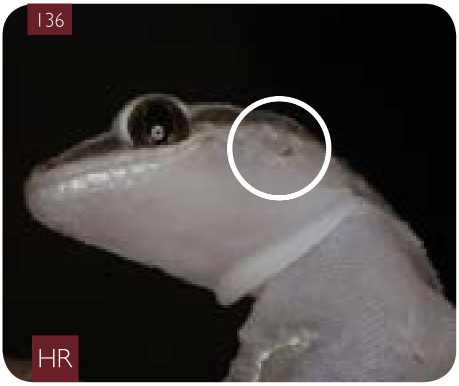
Hearing

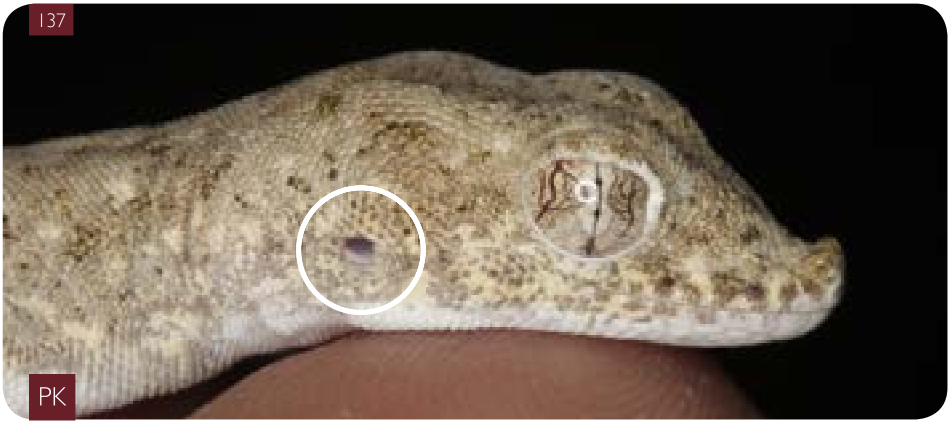
Lizards have external ears on both sides of the head. In reptiles with external ear structures, the tympanic membrane is visible, either nearly contiguous to the surface of the skin, or recessed deeper into the head. Vibrations in the air are picked up by the tympanic membrane and processed into electrical signals which the brain then interprets. Scientists have demonstrated diversity in the sensitivity of hearing and in the decibel ranges that reptiles can detect. Most of the lizards for whom data has been collected show that most species hear in the same range. Sounds in the 500 - 4000 Hz range, with peak sensitivity at 700 Hz, equal to about 24 dB, are reported to be picked up by lizards. The nocturnal Gekkonids can hear both high sensitivity and high frequency sounds which may reach up to 10000 Hz.

The fossorial legless lizards have no ears and lack a tympanic membrane. Hearing is these species is limited to lower frequencies and requires louder sounds to be detected. Amphisbaenians are responsive to low frequencies, below 2000 Hz, with a sensitivity of 50 dB at 1000 Hz. These lizards show the ability to hear or detect ground borne vibrations. Interesting information about hearing in lizards can be found, for example in Baird (1970), Manley (1981) and Christensen-Dalsgaard and Manley (2005).



The ears are visible in diurnal lizards of the family Lacertidae and Scincidae. In the photos, *Acanthodactylus opheodurus* (AO), *Mesalina brevirostris* (MB) and *Trachylepis septemtaeniata* (TS)





The ears are visible in some nocturnal lizards of the family Gekkonidae. In the photos are: *Cyrtopodion scabrum* (CS); *Hemidactylus robustus* (HR); and *Pseudoceramodactylus khobarensis* (PK)

The ears are not visible in some diurnal lizards of the families Scincidae, *Scincus mitranus* (SM) and Agamidae, *Phrynocephalus arabicus* (PA)

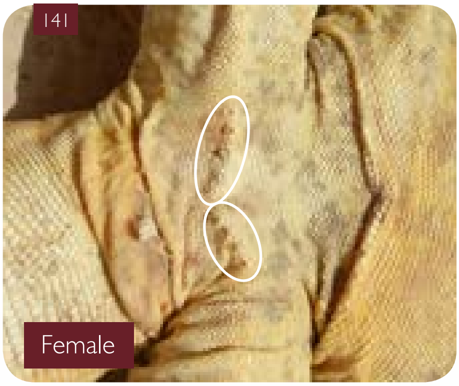
Communication and signalling

Most lizards rely heavily on body language, using specific postures, gestures, and movements to define their territory, resolve disputes, and entice mates. Lizards also communicate with pheromones and use chemical signals. Some species of lizards also use bright colours that are highly visible and increase the chances for mating. Some Gekkonids can communication vocally.

CHEMICAL SIGNALS

Femoral pores are a part of a holocrine secretory gland and appear as a series of holes within a row of scales on the ventral portion of the lizard thigh. Each pore contains a kind of fat which releases pheromones to mark the territory or to attract mates. In some lizard species only the male has these pores and in other species, both sexes have them, with the males being larger.

Many lizard species have conspicuous femoral or preanal glands that secrete chemical compounds especially during the reproductive season (Alberts 1993). These compounds are important in intraspecific communication as they may signal the characteristics and health state of a male (Martín and López 2011). This information may be used by females to select males, or by other males to assess fighting ability or dominance status of the sender (López and Martín 2000, 2011). Chemical compounds are also used for species recognition that may avoid hybridization (Gabirot et al. 2010a,b)



Femoral pores in the Dhub. Males have bigger and lager number of pores than females. Pores can be also seen in the hatching Dhub (*Uromastyx aegyptia*)

The presence of pores and its number is a morphological character used to distinguish between lizard species. In the photos, pores of *Acanthodactylus schmidti* (AS) and *Mesalina adramitana* (MA) can be seen

The largest monitor lizard (*Varanus griseus*) in Qatar has no femoral pores, indicating that they do not use chemicals for communication

Skinks (*Scincus mitranus*) that live in the sand dunes do not have femoral pores

Some nocturnal species do not have femoral pores, like *Cyrtopodion scabrum* (CS) and *Hemidactylus robustus* (HR)

To obtain the secretions we have to gently press around the femoral pores avoiding contact with the fingers to reduce contamination and put the secretions in especial vials

The vials have to be stored cold in the field and frozen (-20°C) in the lab before they can be sent for analysis

Femoral or preanal gland secretions are composed of both lipids and proteins, but some lipophilic compounds (with a high ability to dissolve in fats) seem to be involved in pheromonal communication (Martín and López 2011, Gabirot et al. 2010a, b)). However, the presence and abundance of specific compounds varies widely between species, which might be due to phylogenetic or environmental differences (Martín and López 2006b). Most information on chemical composition of secretions relates to lizard species within the group of Scleroglossa, which are considered to rely more on chemical senses (Cooper 1995). However, these chemicals are only known from a few species of Lacertids (e.g., Martín and López 2011, Gabirot et al. 2010), Gekkonids (Khannoon, 2012) and others families. In contrast, compounds in secretions of lizards within the group of Iguania have been less studied, probably because these lizards seem to rely more on visual cues (Cooper, 1995).

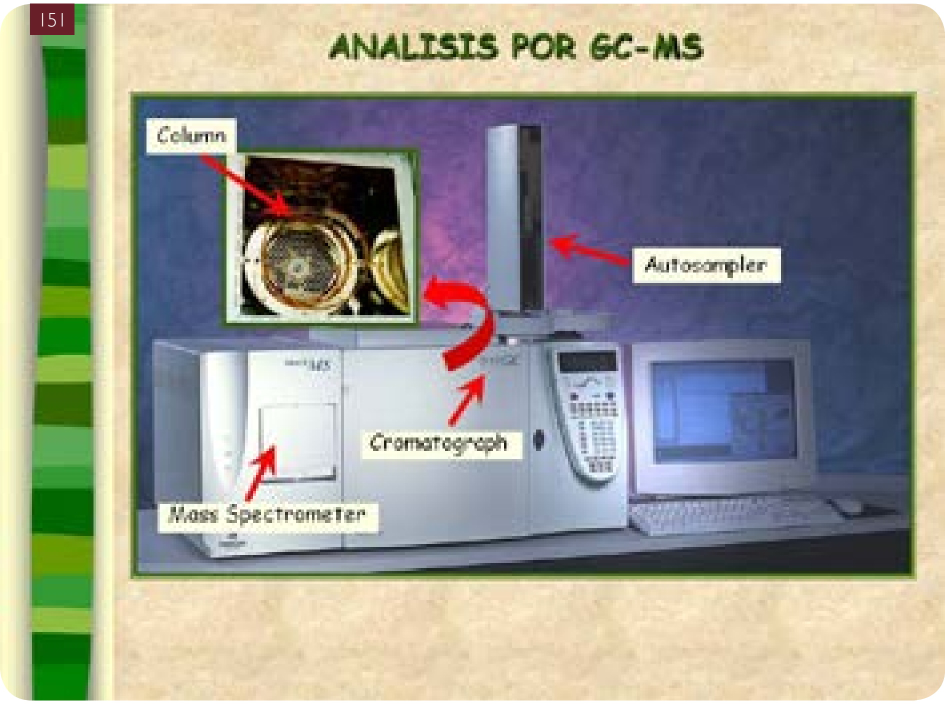
In the desert iguana (*Dipsosaurus dorsalis)*, the waxy lipids released from the femoral pores absorb ultraviolet (UV) wavelengths making them visible to species which can detect UV light (Alberts 1990).

For agamid lizards, only two studies have analyzed the chemical compounds in preanal secretions. One was done with the *Uromastyx harowickii* (Chauhan 1986), and the other one with the Dhub (*Uromastyx aegiptia*) present in Qatar (Martin et al. 2012).

We have examined for the first time the chemical compounds in the femoral secretions of the Dhub *Uromastyx aegyptia*. The study was based on 10 individuals captured in Ras Laffan in Spring 2012. We have found 79 different compounds in the secretions, 37 are exclusively for males, 11 for females and 31 are shared by both sexes.

We also found large individual variation in the type and abundance of some compounds probably due to differences in age, sex and condition of the lizards. Some steroids found are exclusively for plants and not synthesised by the Dhub. The presence of Tocopherol (i.e., vitamin E) is an indicator of the good condition of the lizards captured. To understand what determines the chemical composition of gland secretions of lizards we need more studies using a larger number of individual lizards of both sexes, and also to examine a wider range of lizard species that live under different environmental conditions.

151



ThermoQuest Trace 2000 gas chromatograph from the Physiology laboratory at the National Museum of Natural Sciences (Spanish National Research Council, CSIC) in Madrid (Spain) that was used to analyze the chemical compounds of the Dhub secretions in Qatar (Martin et al. 2011)

COLOUR SIGNALS

Colour traits in lizards play crucial roles in visual communication, but also in thermoregulation, photoprotection, defence and camouflage.

152

153

The lizard *Trapelus flavimaculatus* shows intense bright blue colour during courtship and when it is alarmed

154

The lizard *Trapelus flavimaculatus* has the physiological ability to change from intense blue to brown and vice versa in seconds

155

156

157

The lizard *Phrynocephalus arabicus* can also change the colour of the tip of its tail from brown to intense black colour when it is alarmed. This resembles the tail of a scorpion and may ward off potential predators

Some lizards change colour as their body temperature changes. In the photos a recently hatched Dhub *(Uromastyx aegiptia)* with warm body temperature (brown pale colour) and cold body (dark). This is beneficial as dark colours absorb more UV radiation and thus help to warm up

The colour of lizards also changes after shedding the old skin. A clear example can be seen with the Dhub *(Uromastyx aegyptia)*

163

Gecko of the genus *Stenodactylus* shedding its skin. In this case the colour of the skin provides full camouflage with the background colour of the rock

164

Nearly melanic lizards can be also found but they are rare. In the photo, the Dhub (*Uromastyx aegyptia*)

Reproduction

165

During the mating season lizards search for potential mates to reproduce. Sexual selection is very important and lizards have strong preferences for particular partners. In the photo a couple of Dhubs (*Uromastyx aegyptia*) sharing the same burrow

166

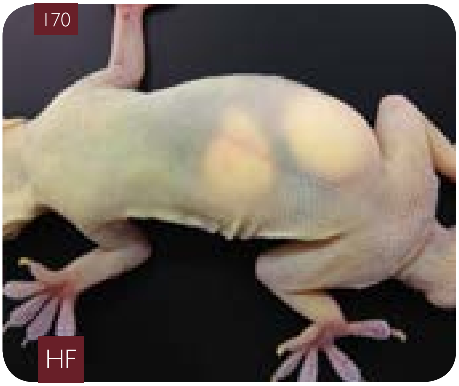
The skink (*Scincus mitranus*) is the only lizard in Qatar that does not lay eggs and instead gives birth to live young. The hot and dry conditions of the sand dunes where these lizards live are not appropriate for egg incubation

167

168

Pregnant female lizards can be recognised by their fat bellies. In the photo, the Dhub's (*Uromastyx aegyptia*)

In some lizard species, but not in all, the eggs are visible through the skin. This is the case for *Hemidactylus robustus*



When lizards have transparent skin, the eggs are visible and can be counted. We can then determine the number of hatchlings females could have if the embryos survive incubation. In the photos *Hemidactylus flaviviridis* (HF) and *Hemidactylus robustus* (HR) can be seen

When the skin in lizards is not transparent and the eggs are not visible, the number of eggs can still be counted by palpation. However, this can be done only in small lizards with thin skins

In lizards with thick skins like in the Dhub (*Uromastyx aegyptia*) it is not possible to count the number of eggs inside the female by palpation

Lizards killed on roads can be examined to determine their sex and reproductive condition. A male lizard can be recognized because it has testicles

Females have ovaries with very small eggs at the beginning of the reproductive season which have yet to be fertilised and develop

176

Laboratory work is very important to examine the reproductive cycles of lizards

177

178

All lizard species in Qatar except the skink (*Scincus mitranus*) lay eggs that are incubated in burrows, under rocks, in soil under vegetation or inside artificial structures. Balance to measure egg mass

179

Recently hatched lizards are very small, with approximately 4 cm of total length in the case of geckos (*Cyrtopodion scabrum*) that hatched in the gardens of Qatar Foundation, with enough humidity and shade. Hatchlings can be smaller in the desert where there may be less humidity in the soil where eggs incubate. Bigger hatchlings normally have higher chances of survival than smaller ones

180

Hatchings directly after coming out from the egg show an opening in their belly that is closed after few days

Locomotion

Most lizards are quadrupedal and have powerful limb musculature. They are capable of rapid acceleration and can also rapidly change direction. Because lizard survivorship depends on ways to escape from predators, running and speed is very important for many species, particularly in deserts habitats.

In Qatar there are two exceptions of lizards that do not run fast using their legs. The lizards without legs (*Diplometopon zarudnyi*) propel themselves entirely by lateral movements, similar to the way snakes move. The skink (*Scincus mitranus*) live in the soft sand of the dunes and are known as diving lizards because they mainly move by lateral trunk bending in the sand, even though they possess short legs.

Maximum sprint-running speed and endurance capacity of lizards has attracted the attention of many scientists all over the world (e.g., Bauwens et al. 1995, Bonine and Garland 1999, Clemente et al. 2008), and specialized equipment has been constructed to measure speed and endurance.

Diurnal lizard species are generally faster runners than nocturnal species, and many of the fastest lizards live in deserts of North America and Australia (Bonine and Garland 1999, Clemente et al. 2008). None of the Qatar lizards have been tested for locomotor capacities in any country. The length of the legs is very important, and those species with longer legs are able to run faster (Bonine and Garland 1999).

Maximal running speeds of lizards are measured by chasing them along a photocell-lined racetrack connected to a computer, or by running them on a high-speed treadmill that can rapidly reach 45 km/h, faster than the fastest lizard (Bonine and Garland 1999).

181

Photocell-lined racetrack connected to a computer used to measure maximal running speeds of lizards. Lizards are chased by hand which simulates a predator

182

High-speed treadmill connected to a computer that can rapidly reach 45 km/h. This is used to measure maximal running speeds of lizards that are chased with the hand simulating a predator

Some small-bodied desert lizards (e.g. racerunners or whiptails, zebra-tailed lizards) can attain speeds that exceed 20 km per hour, which in terms of their body length (less than 50 cm), puts them in a class with the fastest terrestrial mammals. Some larger-bodied species of lizards, such as monitors (*Varanus*), can exceed 30 km/h, and the world's fastest lizard (the spiny-tailed iguana, *Ctenousara similis* from Costa Rica) can reach almost 35 km/h (Garland 1984). Body proportions, such as leg or tail length, and the ability to produce large undulations of the trunk have a large effect on locomotor abilities in terrestrial lizards (Bonine and Garland 1999). Stride length (the amplitude of limb movement) and stride frequency (the rhythm of limb movement) are two components of speed that are directly related to the body geometry, the amount of body curvature, as well as muscle properties, such as the amount of fast-twitch muscle fibre, of an organism (Bonnie 2005).

Endurance (i.e. physical stamina) in lizards is usually measured on motorized treadmills, often at a standard speed of 1.0 km/h. The length of time the lizard can run at this speed is taken as the measure of endurance. Endurance capacity measured in this way is positively related to the daily movement distances of different species in the wild (Garland 1999).

183

Motorized treadmill used to measure endurance in lizards. The standard speed of the treadmill is 1.0 km/h. The length of time the lizard can run at this speed is taken as the measure of endurance. The lizards are chased to keep them moving

One way to calculate the energy lizards expend during locomotion is by measuring metabolic rates while a lizard runs on a motorized treadmill at various speeds (Figure 1). A rubber diaphragm (not shown in the figure) holds the clear plastic mask around the lizard's neck. A pump (not shown either) draws air from the room in from around the neck of the lizard, and out through the plastic tubing. The rate of flow is high enough to ensure that all of the air breathed out by the lizard is captured. The air flows through a drying column that contains chemicals to remove water vapor, and then into sensors to measure the content of carbon dioxide and oxygen in the expired air. By comparing gas concentrations in the expired air with concentrations in the room air, computer programs can calculate the rate of oxygen consumption and carbon dioxide production by the lizards.

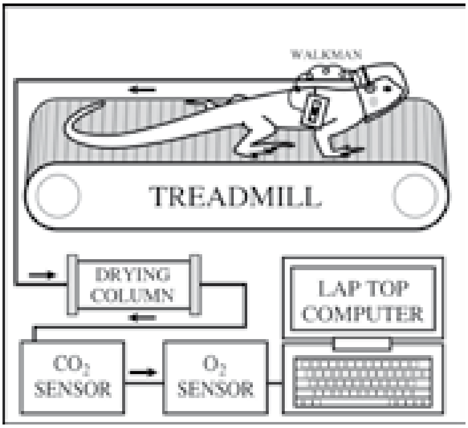


Figure 1. Diagram showing the method used to calculate energy expenditure by measuring oxygen consumption in lizards during locomotion. See text for details (Figure modified from Bennett 1985)

The maximal sprint speeds of lizards and mammals are similar if we take into consideration body mass (Figure 2) (Garland 1983b, Clemente et al. 2009). However, the daily movement distances (actual walking paths) of lizards in the wild are shorter than that of mammals. Lizards move about 1/5 as far as mammals when considering similar body size (Figure 3) (Garland 1983a, 1993, 1999; Goszczynski 1986). Thus larger animals move further than smaller ones.

Running and walking is energetically costly, and to know how much energy the lizards consume during locomotion, scientist measure oxygen consumption while the lizards are walking or running on motorized treadmills at a range of speeds. Comparisons among animals have shown that lizards and mammals have a similar energetic cost of transport. Thus, it is clear that lizards are no less "efficient" than mammals (Figure 4).

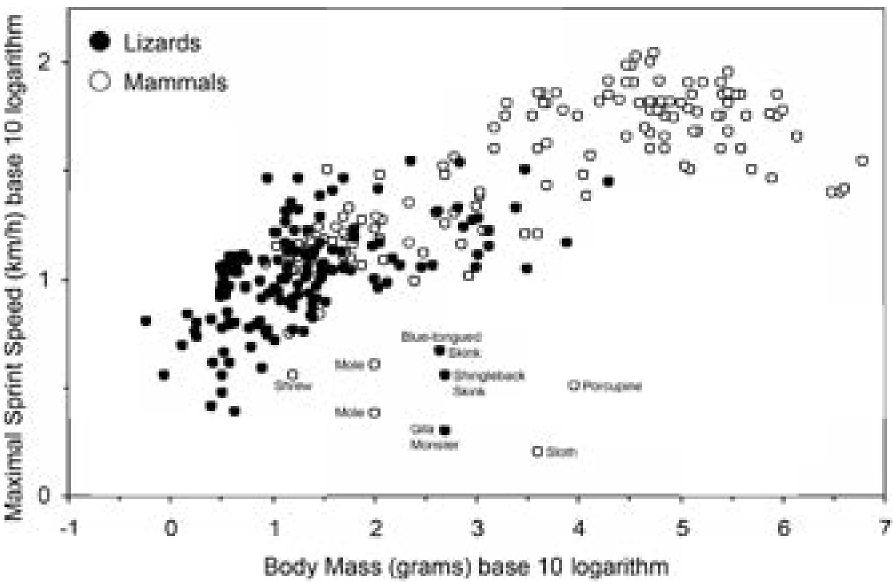


Figure 2. Maximal sprint speeds of lizards and mammals are similar for a given body mass (Figure modified from Clemente et al. 2009)

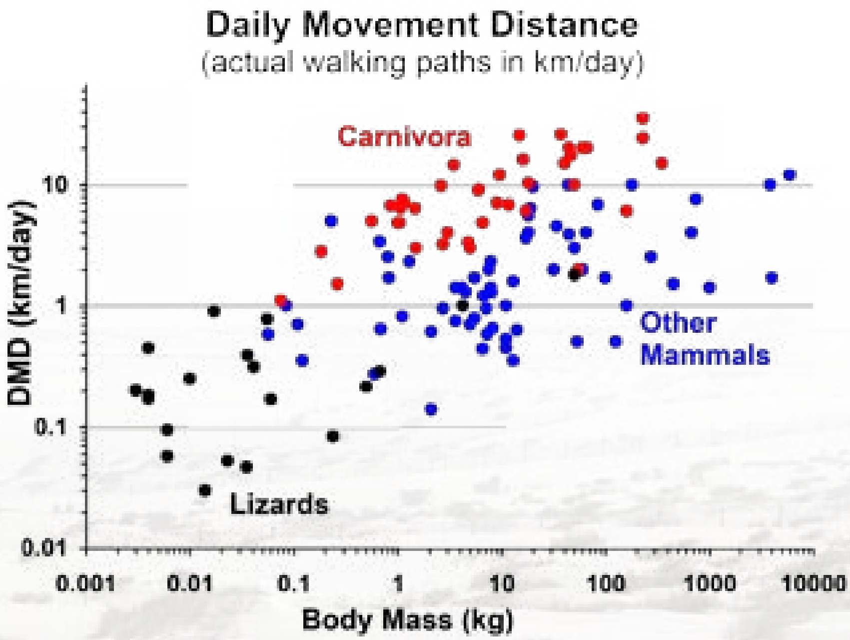


Figure 3. Daily movement distances of lizards and mammals in the field in relation to body mass. Data for the figure taken from different sources (Garland 1983, Goszczynski 1986, Garland 1993, Garland 1999)

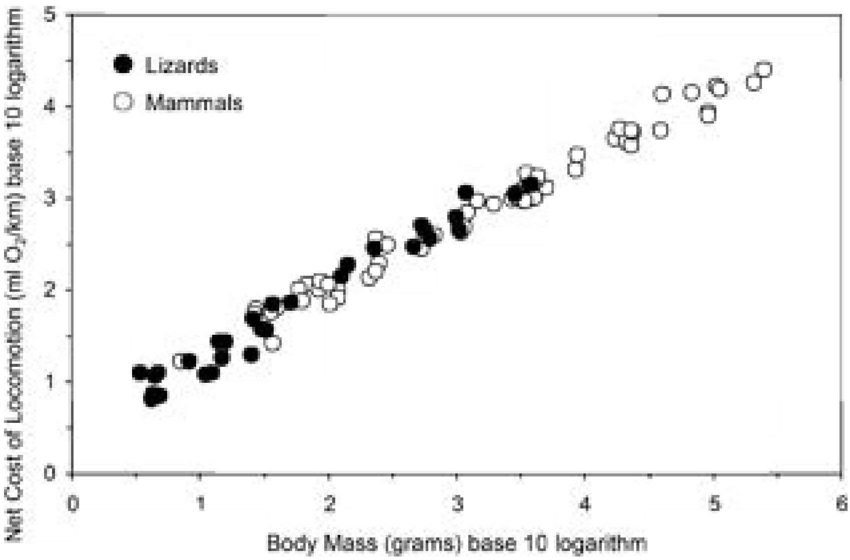


Figure 4. Net cost of locomotion of lizards and mammals for a given body mass. Data for the figure taken from different sources (Taylor et al. 1982, John-Alder et al. 1986, Autumn et al. 1999)

Dhub (*Uromastyx aegyptia*) walking while searching for food in Ras Laffan

185

Dhub (*Uromastyx aegyptia*) running slowly in Al Shamal

186

Dhub (*Uromastyx aegyptia*) running fast in Ras Laffan while being chased by a car

187

The tail in lizards is very important to maintain direction and run efficiently. This is why loosing their tail has a high cost and reduces chances of survival when chased by predators. In the photo, the Dhub (*Uromastyx aegyptia*)

Lizard fingers

Lizards of different species show different type of fingers that are thought to improve their locomotion in the different type of habitats where each species is found. Some species need to run very fast on sand that is moreover sometimes extremely hot. In that case the toes are often fringed with scales adapted for running over loose sand (Luke 1986). Some examples are lizards within the genus *Acanthodactylus* that are in Qatar. Each fringe type is associated with locomotion in specific habitats. Many lizards have fingers with enlarged scales on their toes that increase the surface area exposed to substrate. Some species of nocturnal lizards that move mainly on vertical surfaces have special fingers with lamellae more suitable to adhere in the type of habitat they use (see Chapter I for more details). The number of lamellae under the fingers is also a trait used to differentiate between species.

Fingers of diurnal lizard species

188

Finger of a lizard that dives in the sand dunes. In the photo, *Scincus mitranus*

189

190

191

Fringed toes with scales are adapted for running over loose sand. In the photos, *Phrynocephalus arabicus* (PA), *Acanthodactylus schmidti* (AS), *Acanthodactylus opheodurus* (AO)

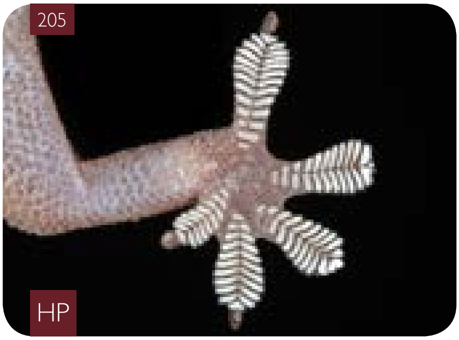
Fingers of lizards that use a mix of soils, seek cover under bushes and live in sandy habitats. In the photos, *Mesalina brevirostris* (MB) and *Mesalina adramitana* (MA)

Fingers of lizards that use hard soils, rocks and bushes. In the photos, *Varanus griseus* (VG), *Uromastyx aegyptia* (UA), *Trapelus flavimaculatus* (TF), *Pristurus rupestris* (PR) and *Trachylepis septemtaeniata* (TS)

Fingers of nocturnal lizard species

Fingers of a nocturnal lizard that uses hard soils, rocks and bushes, but which can also climb walls. In the photo *Cyrtopodion scabrum* (CS) and *Bunopus tuberculatus* (BT)

Fingers of nocturnal ground dwelling lizards. In the photos, *cambiar por Stenodactylus arabicus* (SA), *Pseudoceramodactylus khobarensis* (PK), *Stenodactylus doriae* (SD), *Stenodactylus slevini* (SS)



Fingers of nocturnal lizards that climb on smooth surfaces. In the photos, *Hemidactylus persicus* (HP), *H. flaviviridis* (HF), *H. robustus* (HR)

Tail autotomy

Many lizards can detach their tails to escape from predators, an act called autotomy or self amputation. This is a self-defence mechanism designed to elude a predator´s grasp. The lost part of the tail can be regenerated later. The detached tail will continue to wriggle, creating a deceptive sense of continued struggle and distracting the predator's attention from the fleeing prey animal. The animal can partially regenerate its tail, typically over a period of weeks dependent mainly on food availability, the lizard's physical condition and levels of stress. The new section of the tail contains cartilage rather than regenerating vertebrae of bone, and the skin of the regenerated organ generally differs in colour and texture from its original appearance. The technical term for this ability to drop the tail is "*caudal autotomy*".

In most lizards tail breakage occurs only when the tail is grasped with sufficient force, but some species of geckos can perform true autotomy, throwing off the tail when sufficiently stressed, such as when attacked by ants. Because the tail is a major storage organ for accumulating reserves, lizards will eat a lot to recover the part of the tail that was sacrificed. Conversely, some species have been observed to attack rivals and grab their tails, which were eaten as their opponents fled.

The fact that lizards can regenerate cartilage skeleton and make brand new muscle is of continued interest to scientists who believe learning more about regeneration could be beneficial to humans in the future. Using next-generation technologies, scientists hope to unlock the mystery of what genes are needed to regenerate the lizard tail (Ramachandran et al. 2006) (See Chapter I).

The tail of some lizards (e.g. *Uromastyx aegyptia*) is very strong and it is not easily detached

Lizards can break their tails at different distances from their body, but if they can chose they prefer to lose the smallest amount of tail near to the end

212

The new regenerated section of the tail contains cartilage and the skin differs in colour and texture from its original appearance. However, in some cases it can become difficult to identify the regenerated portion

213

PR

214

MB

Lizards can sometimes regenerate double tails as shown in the photos for *Pristurus rupestris* (PR) and *Mesalina brevirostris* (MB)

Diet of lizards

Most lizards in Qatar are insectivorous; however, the biggest monitor lizard (*Varanus griseus*) is carnivorous and also scavenges for food. This species preys on the Dhub and other smaller lizards. A typical insectivorous lizard, *Trapelus flavimaculatus*, has also been seen preying on a mouse in Qatar (Viju Jose, personal communication).

The Dhub (*Uromastyx aegyptia*) is the only herbivorous lizard in Qatar, where the species eats at least 58 different species of plants (Castilla et al. 2012). It may also consume some insects, which is an observation also reported in other countries (Dickson 1965, Cunningham 2000, Castilla et al. 2012). A recent study conducted in Qatar has shown that the Dhub occasionally scavenges (Castilla et al. 2010).


215

Most lizards in Qatar are insectivorous and need strong bite forces to eat hard beetles

Insects eaten by lizards

216

Scaurus puncticollis Solier, 1838. Tribe Scaurini, Familiy Tenebrionidae, Orden Coleoptera). New record species for Qatar (Mas-Peinado et al. 2013) and new insect species for the World (Ferrer et al. 2014)

217

Meloe coelatus Reiche, 1857. Family Meloidae, Orden Coleoptera. New record species for Qatar (García-París et al. 2013)

218

Adesmia cancellata (Klug, 1830). Tribe Adesmiini, Family Tenebrionidae, Orden Coleoptera

219

Adesmia khaliensis Blair, 1931. Tribe Adesmiini, Family Tenebrionidae, Orden Coleoptera)

220

Trachyderma parvicollis (Baudi di Selve, 1876). Tribe Pimeliini, Family Tenebrionidae, Orden Coleoptera

221

Pimelia arabica Klug, 1830- Tribe Pimeliini. Family Tenebrionidae. Orden Coleoptera) PMP

222

Apentanodes arabicus (Kirchsberg, 1877). Tribe Erodiini, Familiy Tenebrionidae, Orden Coleoptera

223

Prionotheca coronata subsp. Ovalis Ancey, 1881. Tribe Pimeliini, Family Tenebrionidae, Orden Coleoptera

224

Anthia sexmaculata Fabricius, 1787. Family Carabidae, Subfamily Anthiinae

225

Blaps kollarii Seidlitz, 1893. Tribe Blaptini, Familiy Tenebrionidae, Orden Coleoptera

226

Akis spinosa (Linnaeus, 1764). Tribe Akidini, Family Tenebrionidae, Orden Coleoptera

227

Oxycara buettikeri Kaszab, 1979. Tribe Tentyriini, Familiy Tenebrionidae, Orden Coleoptera

228

Thriptera kraatzi Haag-Rutenberg, 1876. Tribe Pimeliini, Family Tenebrionidae, Orden Coleoptera

229

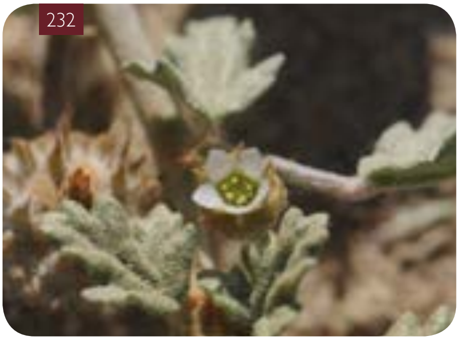
Hyperops pygmea (Koch, 1940). Tribe Tentyriini, Family Tenebrionidae, Orden Coleoptera

Small-medium lizards in Qatar are insectivorous, but they can consume big prey as can be seen in the photo, with *Trapelus flavimaculatus* eating a mouse. This behaviour must be exceptional; however this should be explored further, because animals can change their habits when their preferred food is not available. Lizards are also scavengers particularly in deserts with little food sources

Plants eaten by the Dhub (*Uromastyx aegyptia*) in Qatar

We have examined the diet of *Uromastyx aegyptia microlepis* in Qatar through the analyses of 371 faecal samples collected in the Qatar desert (Castilla et al. 2012). The Dhub is a generalist herbivore that in Qatar forages on at least 37 different plant species belonging to 18 families and 31 genera. The most frequently eaten plant was *Savignya parviflora,* which was present in 92% of the faeces, followed by *Oligomeris linifolia* (85%). Other plants most frequently consumed by the Dhub in Qatar, in the area of Al Kharrara are *Neurada procumbens, Fagonia sp, Schismus sp, Pulicaria undulata, Astragalus eremophilus,Medicago laciniata, Pulicaria undulata and Helianthemum sp*.

The Dhub *(Uromastyx aegyptia)* is the only herbivorous lizard in Qatar


232
Neurada procumbens, Neuradaceae (Flower)


233
Pulicaria undulada, Asteraceae


234
Neurada procumbens, Neuradaceae (Fruit)


235
Medicago laciniata, Leguminosae


236
Savignya parviflora, Brassicaceae (Fruit)


237
Savignya parviflora, Brassicaceae (Flower)

238

Corchorus depressus, Tiliaceae

239

Astragalus eremophilus, Leguminosae

240

Arnebia hispidísima, Boraginaceae

241

Aizoon canariense, Aizoaceae

242

Savignya parviflora, Brassicaceae (Fruit)

243

Fagonia indica, Zygophyllaceae

Dipcadi erythraeum, Liliaceae

Oligomeris linifolia, Resedaceae

Anchusa hispida, Boraginaceae

Malva parviflora, Malvaceae

Helianthemum kahiricum, Cistaceae

Fagonia indica, Zygophyllaceae

Predators

Lizard predators in Qatar include raptors, sea birds, small birds, mammals, snakes and also lizards of different species. Invertebrates also predate on lizards, such as scorpions, spiders and ants. It is quite possible that lizards also cannibalise on their own juveniles and eggs, as happen in other desert areas where food resources are scarce (Castilla and Van Damme 1996). In order to reduce predation and lizard mortality and extinction, it is essential that the habitat has appropriate cover, including vegetation, rocks and burrows.

250

Juvenile Dhub (*Uromastyx aegyptia*) hidden in a burrow. Predation is the most important mortality factor for lizards and having protection in their habitats is of extreme importance

251

The Black kite (*Milvus migrans*) is an opportunistic hunter that also like to scavenge

252

The common Kestrel (*Falco tinnunculus*) is a fast hunter that prey on birds but also capture lizards

253

The Great Black-headed gull (*Larus ichthyaetus*) is a winter visitor in Qatar. Some species of sea birds like gulls are very important predators of lizards particularly when they live in coastal areas or in islands (Castilla 1995)

254

The Grey Heron (*Ardea cinerea*) is present all year in Qatar, and has been observed preying on the Golden grass mabuya (*Trachilepis septemtaeniata*) (Frances Guillespie, personal communication)

255

Shrikes are formidable hunters of insects, lizards and small mammals, and show the behaviour of impaling their bodies on thorns. This helps them to tear their prey into small eatable pieces. It also helps males to impress a female by showing their prey

256

Mesalina adramitana captured by a Shrike in Qatar

257

258

The snake *Rhagerhis moilensis* is common in Qatar and predate on lizards

259

260

The Arabian horned viper (*Cerastes gasperettii*) predate on lizards

261

262

The Arabian horned viper (*Cerastes gasperettii*) hidden near a bush and viper tracks in the sand in Mesaieed, Qatar

263

264

The monitor lizard (*Varanus griseus*) is a hunter that also prey on lizards, even when they are big like the Dhub (*Uromastyx aegyptia*) (below)

265

The Rueppell´s sand fox (*Vulpes rueppelli*) is not common in Qatar. It is an omnivore solitary forager that eats anything that can find. It is mainly a insectivore, but also eats lizards, eggs, small mammals and roots

266

The common red fox (*Vulpes vulpes*) is widespread in Qatar and eats a large variety of animal prey and fruits

267

Domestic cats are very important predators that can exterminate large lizard populations in islands, gardens and urban zones

268

269

270

271

Mammal predators can be identified by their tracks and the presence of their burrows in the desert

272

273

Scorpions are important predators of lizards in arid areas (Castilla et al. 2014). The black scorpion (*Androctonus crassicauda*) and the yellow scorpion (*Buthacus yotvatensis*) are common in Qatar

274

275

Different species of invertebrates also predate on lizards and particularly in arid zones

V
CURRENT KNOWLEDGE ABOUT THE QATAR LIZARDS

Current knowledge about the lizards of Qatar

History of the discovery of lizard species in Qatar

The majority of lizard species that are present in Qatar were discovered in other parts of the world since the end of the XIX century, except for two species (*Stenodactylus arabicus and Stenodactylus slevini*) that are new for the world having been discovered since 1957 (Table 1, Figure 1).

The discovery of lizard species in Qatar is quite recent when compared to their history in other countries. The first two lizards described for Qatar (*Mesalina adramitana* and *Stenodactylus slevini*) were discovered only in 1980 (Arnold 1980), while they both were known to exist in the world since 1917 and 1957 respectively. (Figure 1). After that, the majority of Qatar lizards (n= 16) were described in 1988 by an Egyptian scientist (Mohammed 1988). After a period of 16 years, a new species was reported for Qatar (*Pristurus rupestris*) by Qatari experts (State of Qatar 2004). In 2012 an additional two species were described by a team headed by scientists of the Spanish National Research Council (CSIC) (Metallinou et al. 2012).

Only recently, a large proportion (33%, n= 7) of the lizard species present in Qatar have been described by the Ministry of the Environment in collaboration with Qatar Foundation and an international team of scientists (Cogălniceanu et al. 2014).

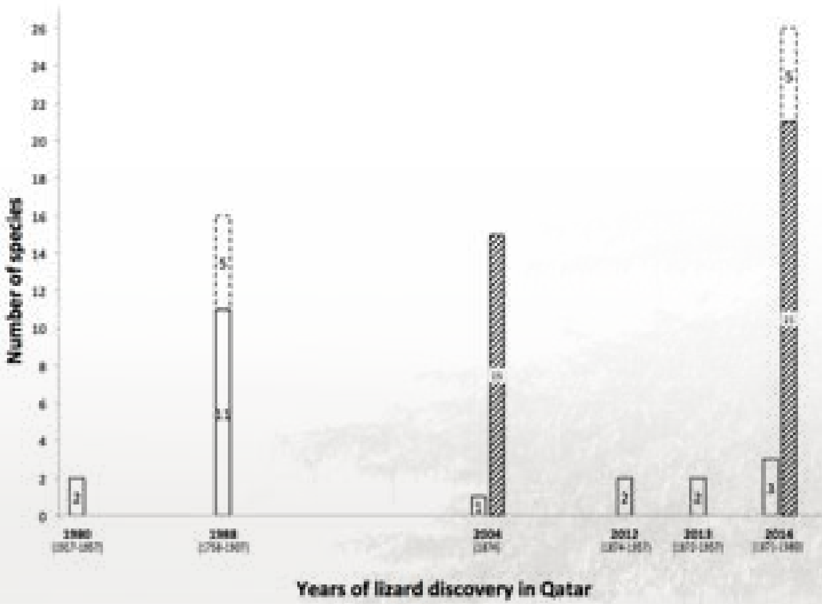


Figure 1. History of the discovery of lizard species in Qatar over time. Numbers in brackets represent the range of years when the species for each column were first discovered in the world. The numbers inside the columns are the years of lizard discovery in Qatar. Dashed columns indicate the number of species reported for Qatar in biodiversity reports. Five lizard species described in 1988 are not included within the 21 species described in 2014, suggesting that the number of lizard species in Qatar must be larger. See Table 1 in this chapter and chapter VII for more details.

Five of the species described by Mohammed in 1988 have not been detected in the recent study by Cogălniceanu et al. (2014). The species could have been mistaken in 1988, but they may have not been currently detected in Qatar if their populations have dramatically decreased, or if the species have became extinct since it first being described (see Chapter VII for more details).

Interestingly, in 2013 two new lizard species have been recorded for the first time in Qatar. No one, locally or internationally, saw them before in Qatar. The species are the Persian leaf-toed gecko (*Hemidactylus persicus*) (Castilla et al. 2013) that has been only found in Halul island, and the Gulf sand gecko (*Pseudoceramodactylus khobarensis*) (Valdeón et al. 2013).

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Research paper

First record of a gecko species to the fauna of Qatar: *Hemidactylus persicus* Anderson, 1872 (Gekkonidae)

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ABSTRACT
We report the discovery of a gecko species, the Persian leaf-toed gecko *Hemidactylus persicus* Anderson, 1872 (Gekkonidae) in Qatar, found on Halul Island. According to the Qatar National Biodiversity Surveys and the available international literature *H. persicus* was not previously rec in Qatar. Its known range covers the north east of the Arabian Peninsula, Bahrain, the United A Emirates, and south western Asia. Our findings bridge the current geographic gap in the known distribution of the species from Saudi Arabia to Asia. We believe that the species could also be pr in the Qatar peninsula. A thorough field survey is needed in order to map the range of this spec the State of Qatar.

Keywords: Halul Island, lizard, mapping, biodiversity, wildlife conservation, Arabian Gulf

QScience Connect — A Qatar Foundation Academic Journal

OPEN ACCESS

Research article

On the presence and distribution of the Gulf sand gecko, *Pseudoceramodactylus khobarensis* Haas, 1957 (Reptilia: Squamata: Gekkonidae) in Qatar

Aitor Valdeón[1,2], Aurora M. Castilla[3,4,*], Dan Cogălniceanu[5], Alberto Gosá[2], Ali Alkuwary[6], E O H Saifelnasr[7,8], Elsa Naumann[9], Paloma Mas-Peinado[10], Renee Richer[11], Ahmad Amer Mohd Al-Hemaidi[12]

ABSTRACT
The Gulf sand gecko (*Pseudoceramodactylus khobarensis* Haas, 1957) is a nocturnal gecko endemic to the Arabian Gulf countries. In this study we report the presence of this species in Qatar for the first time. Our findings bridge one of the current geographic gaps in the known distribution range of this species. In Qatar, the species has been found on the mainland and on two islands occupying coastal salty habitats with shrubs. The islands are the smallest where this species is known to occur. We believe that this gecko species is more widely distributed in Qatar than we report here and that an extensive inventory is required to map the full range of the species in Qatar and also in other countries of the Arabian Gulf.

Keywords: Arabian Gulf, reptile, range, *Stenodactylus khobarensis*, Atlas, biodiversity

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www.zookeys.org

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

A preliminary report on the distribution of lizards in Qatar

Dan Cogălniceanu[1], Aurora M Castilla[2,3], Aitor Valdeón[4,5], Alberto Gosá[4], Noora Al-Jaidah[2], Ali Alkuwary[6], Essam O. H. Saifelnasr[7,8], Paloma Mas-Peinado[9], Renee Richer[10], Ahmad Amer Mohd Al-Hemaidi[11]

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Abstract
We have updated the list of the lizard species present in Qatar and produced the first distribution maps based on two field surveys in 2012 and 2013. We used the QND95/Qatar National Grid with a grid of 10 × 10 km squares for mapping. Our results show the occurrence of 21 lizard species in Qatar, from the 15 species indicated in the last biodiversity report conducted in 2004. The most abundant family found in Qatar is Gekkonidae with nine species (*Bunopus tuberculatus*, *Cyrtopodion scabrum*, *Hemidactylus robustus*, *H. flaviviridis*, *H. persicus*, *Stenodactylus arabicus*, *S. slevini*, *S. doriae*, *Pseudoceramodactylus khobarensis*), followed by Lacertidae with four species (*Acanthodactylus schmidti*, *A. opheodurus*, *Mesalina brevirostris*, *M. adramitana*), Agamidae with three species (*Trapelus flavimaculatus*, *Uromastyx aegyptia*, *Phrynocephalus arabicus*), Scincidae with two species (*Scincus mitranus*, *Trachylepis septemtaeniata*), and Varanidae (*Varanus griseus*), Sphaerodactylidae

Table 1. List of lizard species and their families cited for Qatar. The author who first described the presence of the species in the world and the authors who recorded the species in Qatar for the first time are indicated. The species indicated in maroon have not been found

Scientific name	Common name
Varanus griseus	Monitor lizard
Uromastyx aegyptia	Dhub
Phrynocephalus arabicus	Toad-headed agama
Trapelus flavimaculatus	Yellow-spotted agama
Pseudotrapelus sinaitus	*Sinai agama*
Acanthodactylus schmidti	*Schmidt´s fringe-toed lizard*
Acanthodactylus scutellatus	*Nidua fringe-fingered lizard*
Acanthodactylus opheodurus	*Arnold´sfringe-toed lizard*
Acanthodactylus boskianus	*Bosk´s fringe-toed lizard*
Mesalina brevirostris	*Blanford´s short-nosed desert lizard*
Mesalina adramitana	*Hadramaut sand lizard*
Pristurus rupestris	*Blandford´s semaphore gecko*
Trachylepis septemtaeniata	*Golden grass mabuya*
Scincus mitranus	*Eastern skink*
Scincus scincus	*Sand fish*
Chalcides ocellatus	*Ocellated skink*
Diplometopon zarudnyi	Zarundnyi´s worm lizard
Cyrtopodion scabrum	Rough-tailed gecko
Bunopus tuberculatus	Baluch rock gecko
Pseudoceramodactylus khobarensis	Gulf sand gecko
Hemidactylus persicus	Persian Leaf-toed gecko
Hemidactylus flaviviridis	Yellow-bellied house gecko
Hemidactylus robustus	Heyden´s gecko
Stenodactylus doriae	Middle Eastern sand gecko
Stenodactylus arabicus	Arabian sand gecko
Stenodactylus slevini	Slevin´s short-fingered gecko

in Qatar surveys conducted in 2012 and 2013. It is also shown if the lizard species are diurnal (orange), fosorial (grey) or nocturnal (blue)

First description	Family	First recorded in Qatar
Daudin, 1803	Varanidae	Mohammed 1988
Forskål, 1775	Agamidae	Mohammed 1988 (cited as *U. microlepis*)
Anderson, 1894	Agamidae	Mohammed 1988 (cited as *P. nejdensis*)
Rüppell, 1835	Agamidae	Mohammed 1988 (cited as *Agama sinaita*)
Heyden, 1827	*Agamidae*	*Mohammed 1988*
Haas, 1957	*Lacertidae*	*Cogalniceanu et al. 2014*
Audouin, 1827	*Lacertidae*	*Mohammed 1988*
Arnold, 1980	*Lacertidae*	*Cogalniceanu et al. 2014*
Daudin, 1802	*Lacertidae*	*Mohammed 1988*
Blanford, 1874	*Lacertidae*	*Mohammed 1988 (cited as Eremias brevirostris)*
Boulenger, 1917	*Lacertidae*	*Arnold 1980a*
Blanford, 1874	*Sphaerodactylidae*	*Ministry of Environment 2004*
Reuss, 1834	*Scincidae*	*Mohammed 1988 (cited as Mabuya aurata)*
Anderson 1871	*Scincidae*	*Cogalniceanu et al. 2014*
Linnaeus,1758	*Scincidae*	*Mohammed 1988*
Heyden, 1827	*Scincidae*	*Mohammed 1988*
Nikolsky, 1907	Trogonophiidae	Mohammed 1988
Heyden, 1827	Gekkonidae	Mohammed 1988 (cited as *Gymnodactylus scaber*)
Blanford, 1874	Gekkonidae	Mohammed 1988
Haas, 1957	Gekkonidae	Valdeón et al. 2013
Anderson, 1872	Gekkonidae	Castilla et al. 2013
Rüppell, 1835	Gekkonidae	Mohammed 1988
Heyden, 1827	Gekkonidae	Mohammed 1988 (cited as *H. turcicus*)
Blanford, 1874	Gekkonidae	Metallinou et al. 2012
Haas, 1957	Gekkonidae	Metallinou et al. 2012
Haas, 1957	Gekkonidae	Arnold 1980b

Scientists at Qatar University have studied the physiology of some Qatar lizards and have published two books (El-Sherif and Al-Thany 2000, Al-Thani and El-Sherif 2002), and also described the presence in Qatar of some of the species commented by Mohammed (1988).

In 2004, the Supreme Council for the Environment and Natural Reserves (SCERN) of Qatar elaborated a Biodiversity Report (State of Qatar 2004) where they included 15 species of lizards (Figure 1). However, the knowledge about lizard biodiversity in Qatar in 2004 was broader internationally (18 species described) (Arnold 1980a, 1980b, Mohammed 1988) than inside the Qatar country (15 species described) (State of Qatar 2004). Considering all available information, the number of known lizard species in 2004 was 19 (Figure 1).

These findings clearly reflect the need to collect all references available about the species present in a given country. This requires a lot of intense work and a deep review of the literature, searching though many different libraries, bookstores, universities and database sources from different countries. Not doing so implies having incomplete historical information about the topic of interest.

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Library at the Ministry of Environment in Qatar

International literature published about the Qatar lizards

Most aspects of the biology and ecology of the lizard species that occur in Qatar have not been studied in Qatar or elsewhere except for three species (Figure 2). The monitor lizard (*Varanus griseus*) has been extensively studied in Africa and Arabia and we found 266 international publications. The Dhub (*Uromastyx aegyptia*) has also been well studied in Africa and Arabia, with 72 studies found, and the house gecko (*Hemidactylus flaviviridis*) is the best studied lizard, with 424 studies found (Figure 2). For most Qatar lizard species there is less than 20 studies published, and for six species less than ten studies. In addition, many of the studies are descriptions of new records for given geographic areas.

In Qatar there are no studies about the biology, ecology, physiology or distribution of the lizard species living in the country, except for few recent studies (Arnold 1980a, b, Mohamed 1988, El-Sherif and Al-Thani 2000, Al-Thani and El-Sherif and 2002, Castilla et al. 2011 a, b, Metallinou et al. 2012, Castilla et al. 2013, Herrel et al. 2014, Martín et al. 2012, Cogălniceanu et al. 2014, Valdeón et al. 2013, Valdeón et al. in press). The best known and best studied lizard in Qatar is the Dhub.

570

The first steps for the creation of this book started in 2011 in Qatar Foundation when QEERI was established

571

The Minister Office in MOE provides the best services to guarantee excellence to the published books

572

The new scientific discoveries presented in this book have been also disseminated at International congresses and national public events in Qatar

573

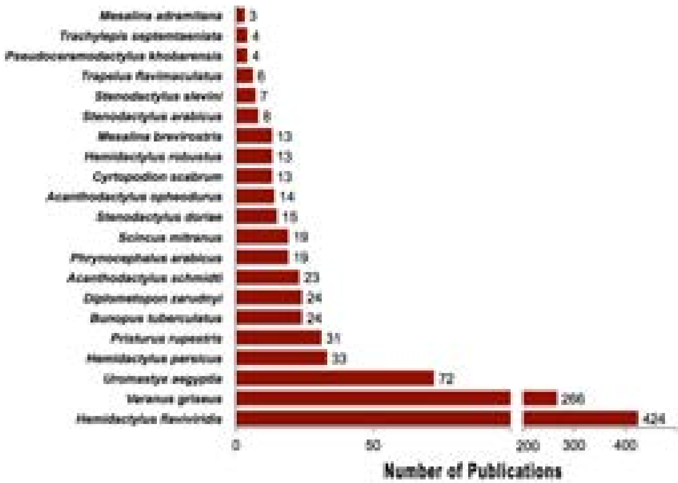


Figure 2. Number of scientific studies published in peer reviewed international journals about the lizard species present in Qatar. The source from international data bases ISI Web of Knowledge (August 2013)

Body size of Qatar lizards

Most Qatar lizards have a total body length of medium size, measuring approximately 15 to 20 cm (Figures 3, 4). Nocturnal lizards are smaller in size than diurnal lizards except for the yellow-bellied house gecko (*Hemidactilus flaviviridis*) that is the largest nocturnal gecko. The second exception is the diurnal Blandford´s semaphore gecko (*Pristurus rupestris*) which is the smallest lizard in Qatar, showing no more than a total body length of 7 cm. The largest lizards are diurnal, the carnivorous monitor (*Varanus griseus*) is the largest one, and can be bigger than one meter. The herbivorous Dhub (*Uromastyx aegyptia microlepis*) is the second largest, and can reach 70 cm in different populations throughout Qatar.

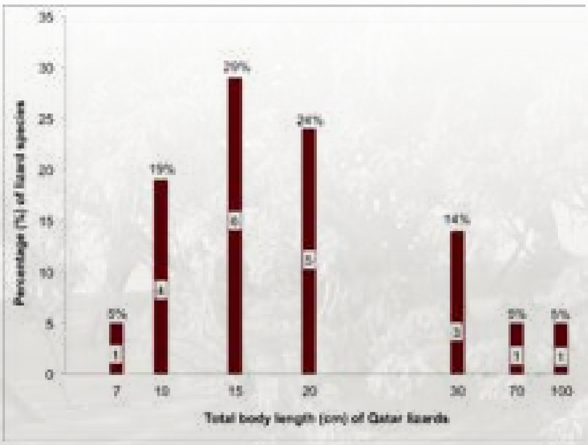
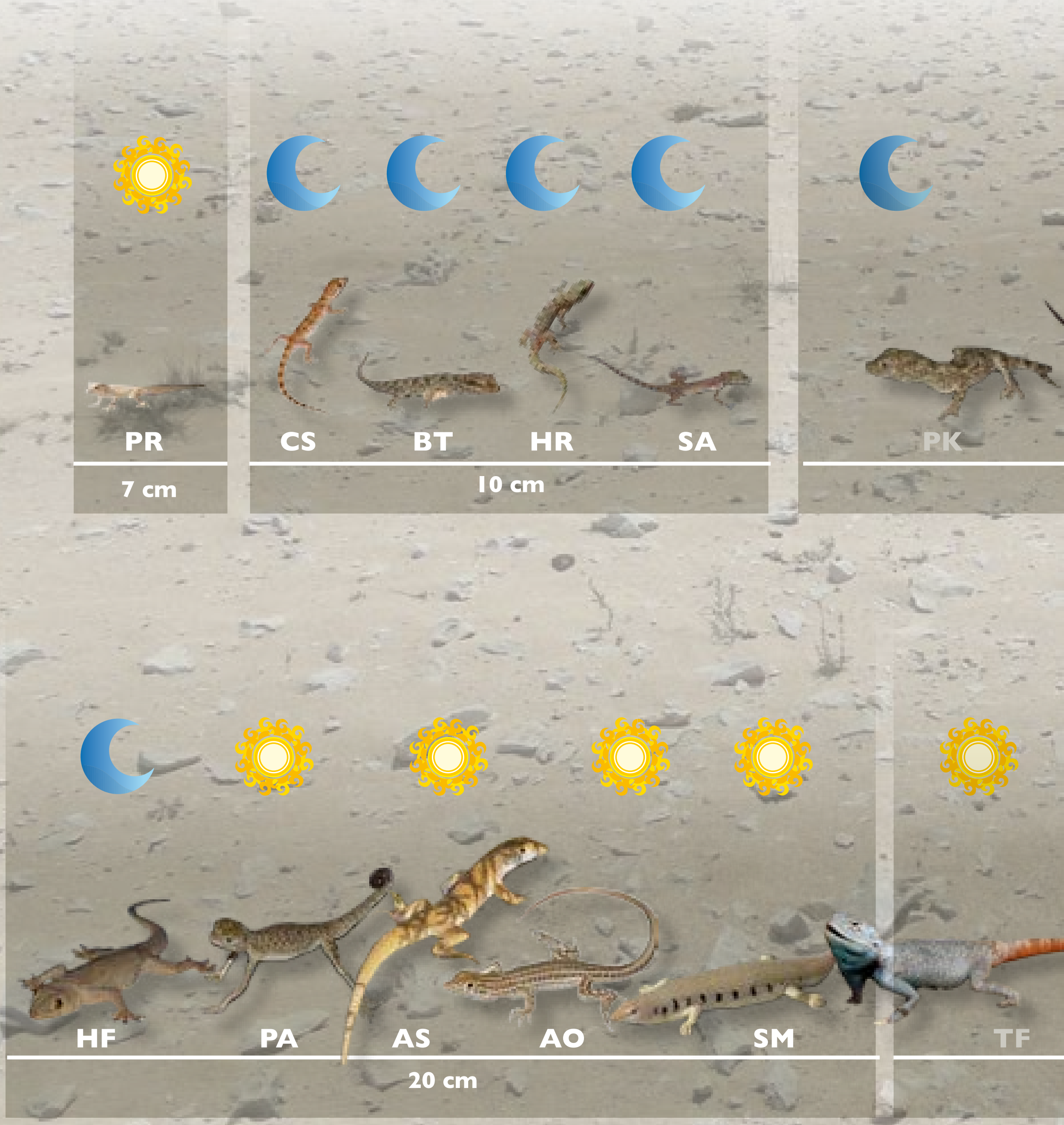
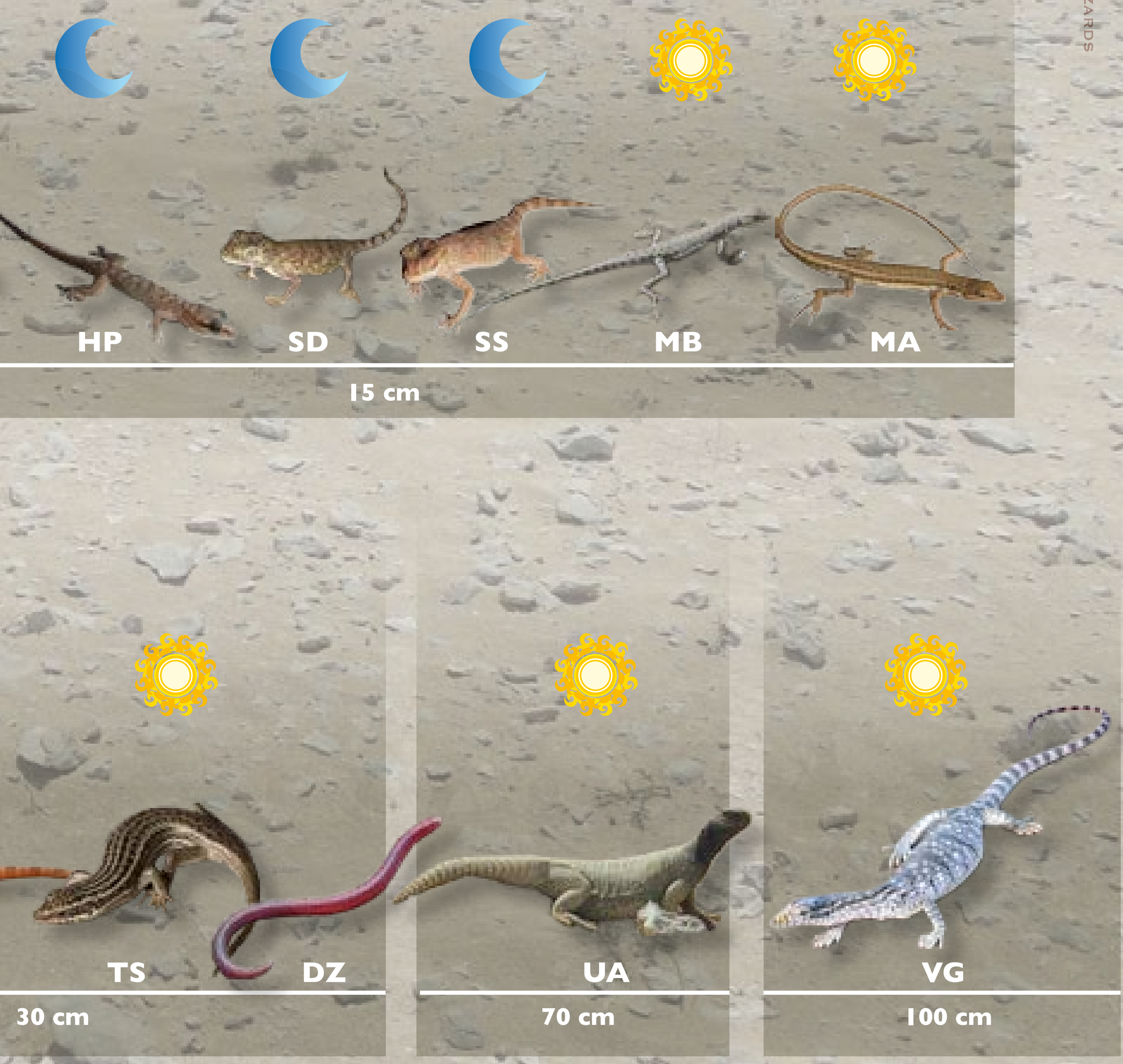


Figure 3. Percentage of lizard species having different body size in Qatar

Figure 4- Approximate maximum body size that can reach the lizard species present in Qatar. It is shown if they are diurnal or nocturnal. The name code corresponds to the first letter of the genus and the first letter of the species for each lizard species (see the complete scientific names in Table 1)




HP
SD
SS
MB
MA
15 cm
TS
DZ
30 cm
UA
70 cm
VG
100 cm

Lizard richness in Qatar

During the field surveys conducted between 2012-2013 we observed from 5 to 35 individual lizards per day (average of 19 individuals/ day). Based on measurements of relative abundance, there are four species of lizards that appear to be the most abundant. These are *Bunopus tuberculatus, Cyrtopodion scabrum, Mesalina brevirostris*, and the Dhub (*Uromastyx aegyptia*) (Figures 5, 6). Preliminary estimations of lizard species richness have indicated that lizard richness in Qatar varied largely across the country, with 1 to 11 species present per grid square (Cogălniceanu et al. 2014).

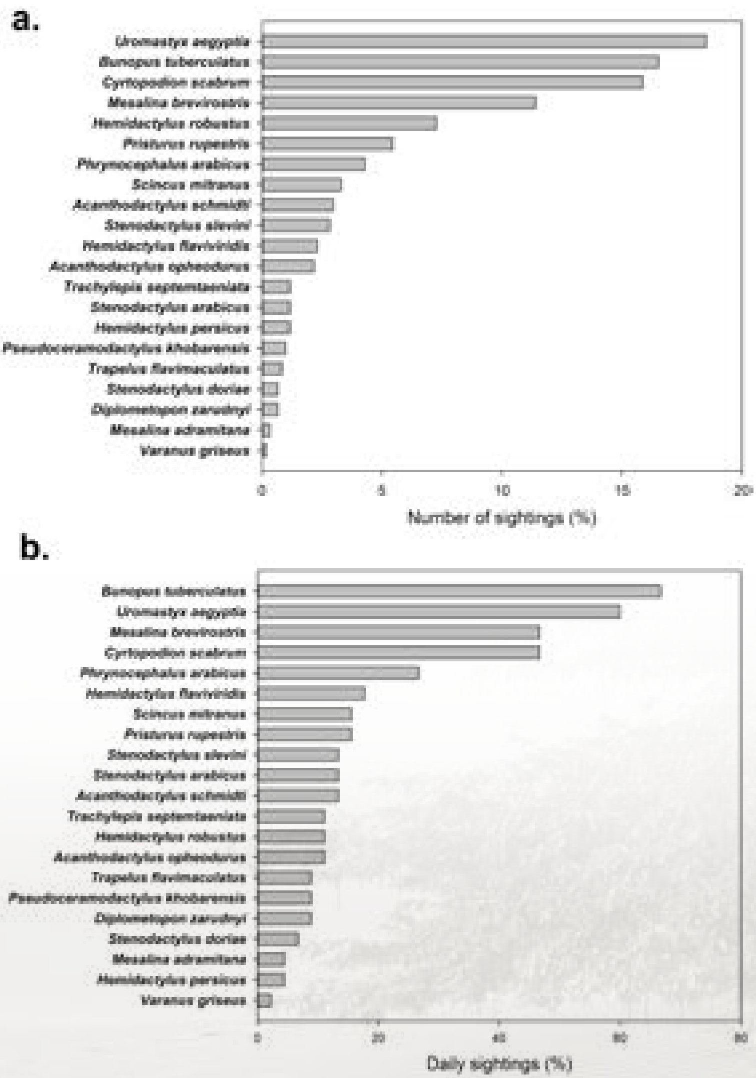


Figure 5. Estimates of lizard species richness based on (a) the proportion of sightings of a certain species from the total number of sightings (n = 617), and (b) the presence of a species per day from the total number of fieldwork days (n = 45)(Cogălniceanu et al. 2014)

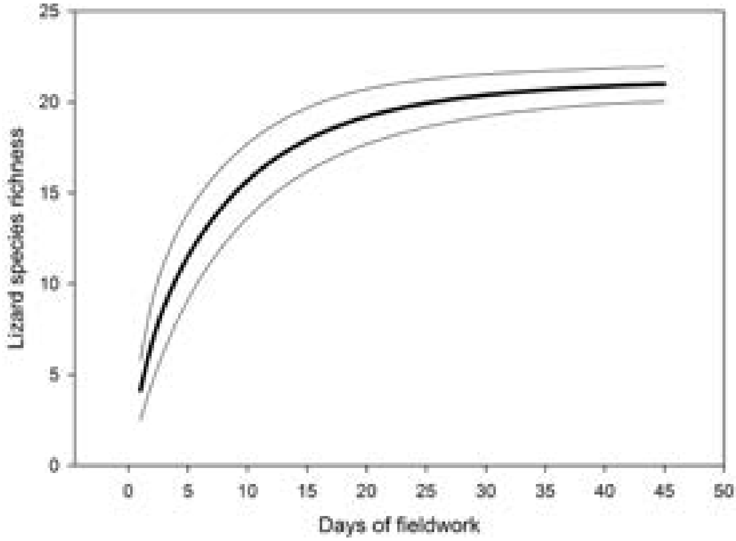
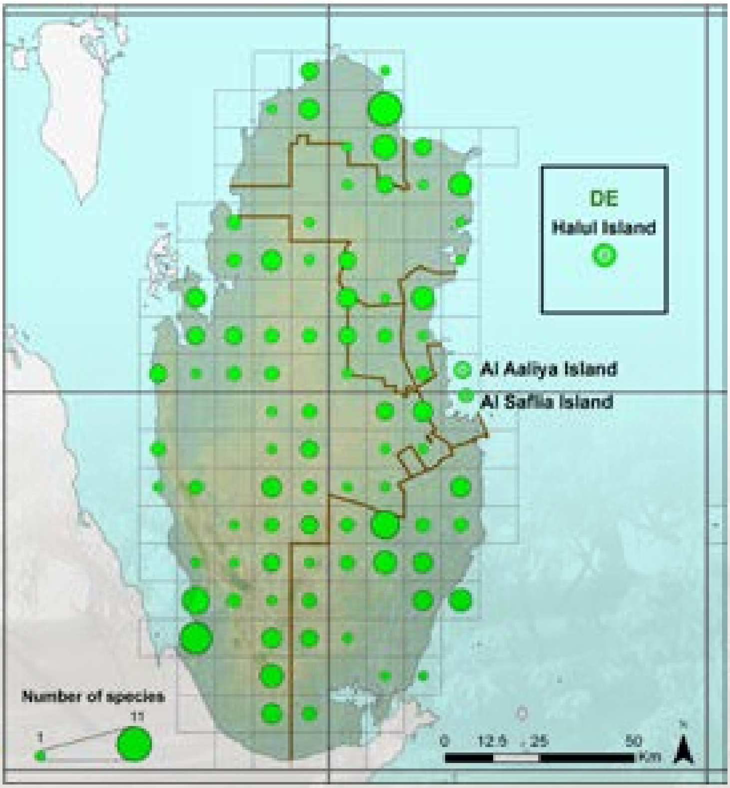


Figure 6. Species accumulation curve (bold line) reflecting lizard species richness based on presence-absence data (Cogălniceanu et al. 2014)



Lizard species richness based on preliminary incomplete surveys

Habitats used by lizards in Qatar

URBAN HABITATS

278

Education City, Qatar Foundation, Doha

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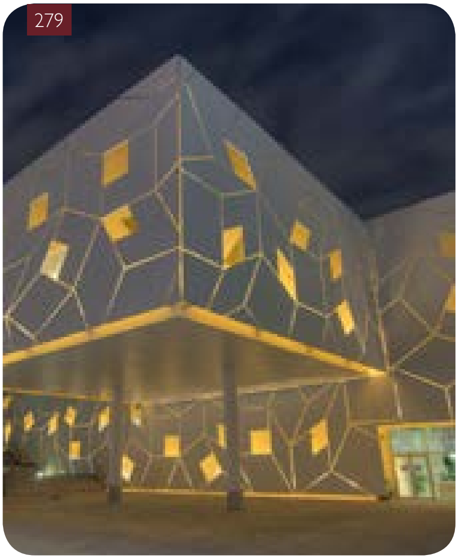
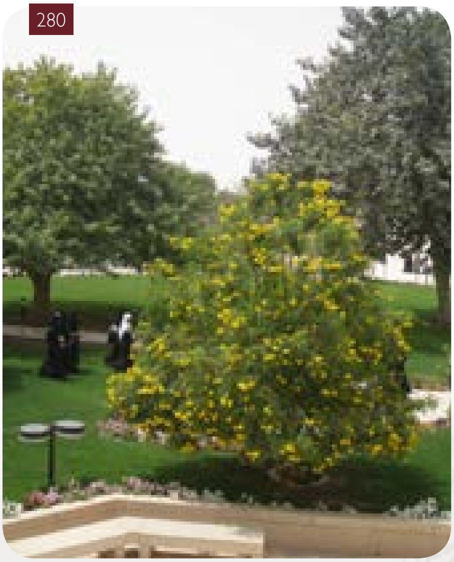


Liberal Arts and Science (LAS) building, Education City, Doha

280



Qatar University, Doha

281

Qatar Foundation housing facilities, Doha

The natural habitats of many lizards have disappeared in Qatar. However some species have learnt to live in contact with humans and benefit from the green areas and the lights that attract many insects that they can capture at night.

ANTHROPIC HABITATS

282

Artificial channel in Abu Nakhla

283

Palm farm in Alwakra

284

Valve pit in Ras Laffan

285

Zubara ruins

Lizards also benefit from artificial sources of water and green areas in the desert. Artificial structures and abandoned villages also provide with cooler and protected zones for egg laying and incubation.

BUSHES ON SOIL AND SAND

286

Ras Laffan

287

Al Aaliya island

288

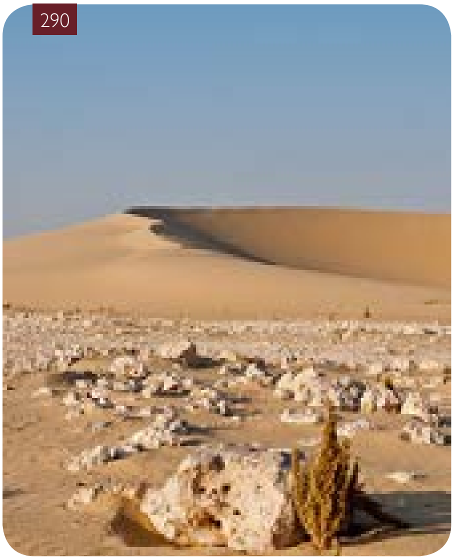
Fuwairit

289

Dukhan

Open areas with sparse bushes are the most common habitats where the majority of lizards can be seen in Qatar. However, even if these habitats may look quite similar, they are not. Small differences in the type of soil, with more or less sand, with different type of stones, or different density of bushes makes a big difference for the lizard species that occupy the habitats.

DUNES

290

Dunes without vegetation in Al kharrara

291

Dunes without vegetation in the South of Qatar

292

Dunes with vegetation in Alkhor

293

Dunes with vegetation in Mesaied

The dunes are home to only some species of lizards because it requires special adaptations to live on them. The presence of vegetation in the dunes also makes a difference to host different lizard species. Little burrows can be dug near the roots of the plants where lizards can put their eggs for incubation. In dunes with no vegetation at all, the skinks do not lay eggs that dehydrate fast in the hot sand; but give birth to fully developed baby skinks.

HILLS AND ROCKY SOILS

294

Abu Samra

295

Zekreet

296

Zekreet

297

Zekreet

Qatar is mainly flat with few elevations. Hills are visited by mammals, snakes and raptors which are important predators of lizards, and lizards are not frequently seen in these areas.

SOILS OF EXTREME ARIDITY

298

299

Lizards are also found on extremely dry soils. That makes scientists very enthusiastic to discover how animals can survive under such conditions.

BEACH

300

Al Aaliya island

301

Beach in Halul island

Under conditions of high aridity where lizards can not find food inland, some species have adapted to consume marine prey living in coastal areas. Lizards on some of Qatar's islands can be found very near to the sea line.

302

Acquiring information about the precise current knowledge of the lizards and their environment requires large efforts, intense documentation and discussion

303

Working on Biodiversity also requires examining scientific collections. In the photo a dugong skeleton as an example

VI
IDENTIFICATION AND DISTRIBUTION OF LIZARDS IN QATAR

DIURNAL LIZARDS

Varanus griseus

Uromastyx aegyptia

Phrynocephalus arabicus

Trapelus flavimaculatus

Acanthodactylus schmidti

Acanthodactylus opheodurus

Mesalina brevirostris

Mesalina adramitana

Pristurus rupestris

Trachylepis septemtaeniata

Scincus mitranus

Desert monitor
(Varanus griseus)

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English name: Desert Monitor

Scientific name: *Varanus griseus*

First description: Daudin, 1803

Family: Varanidae

Synonyms: *Tupinambis griseus*

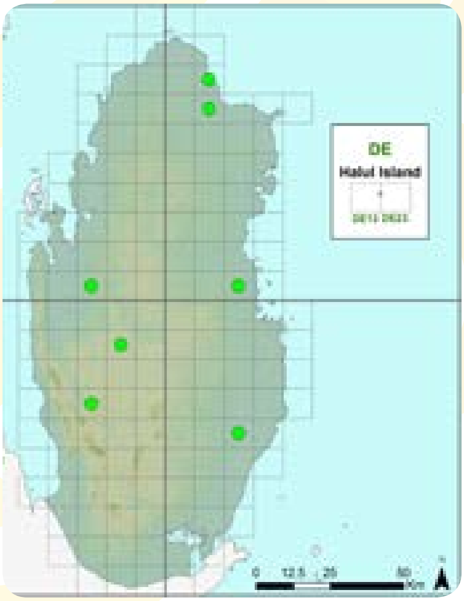
Similar species: None in Qatar

Habitat and Ecology

This is the largest lizard in Qatar and can reach a total length of more than one meter. It is active during the day and can be found in open rocky areas with vegetation and in sandy areas. This is a solitary lizard and occupies large territories. It is a carnivorous hunter that eats other lizard species including the Dhub. The monitor also eats birds, eggs and carrion. Females lay eggs in deep burrows. This was an abundant species in Qatar but now it is difficult to see

World distribution

The species is distributed in North Africa and West and Central Asia, Turkey, Iraq, Iran, Arabian Peninsula, Qatar, Kazakhstan, Uzbekistan, Turkmenistan, Afghanistan, Tajikistan and Kyrgyzstan, Pakistan and India

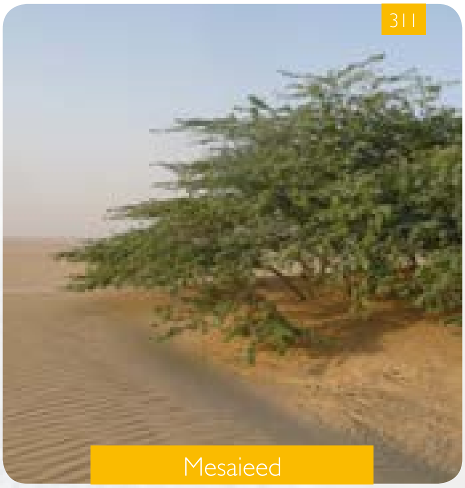


Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

This is a very well studied species in other countries over its range. We have found 266 international scientific publications about ecology, physiology, behaviour, biogeography and genetics of the species. However, no information about the monitor lizard is available for Qatar



311

Mesaieed

312

Adult monitor

313

Collecting data during the field surveys including location and soil type in order to describe the habitat of the lizards

314

Young female monitor rescued and released back in to the field. The lizard fell down accidentally and was trapped for few days not being able to climb out

315

Learning to identify the species with the help of scientific collections

Spiny-tailed lizard
(Uromastyx aegyptia)

316

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Rawdat Rashed

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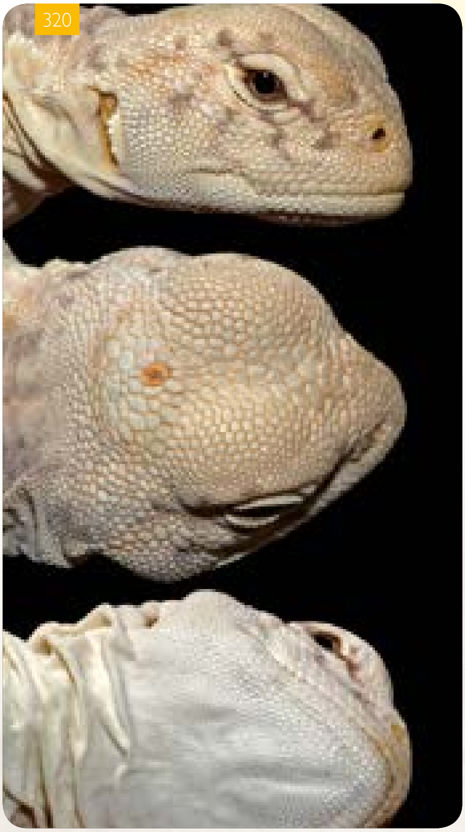

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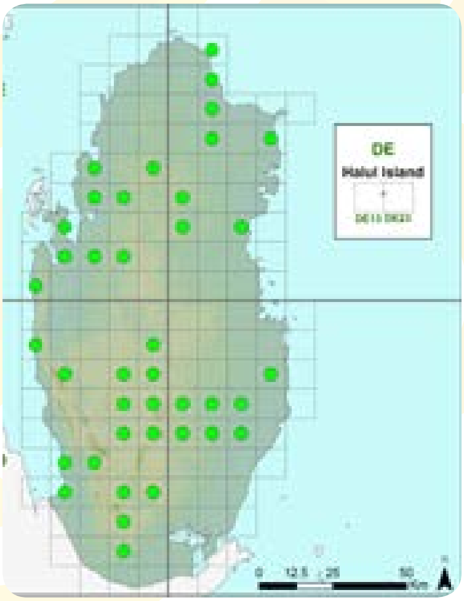
321

English name: Spiny-Tailed Agama
Scientific name: *Uromastyx aegyptia microlepis*
First description: Forskal, 1775
Family: Agamidae
Synonyms: *Lacerta aegyptia*
Similar species: None in Qatar

Habitat and Ecology

The Dhub is the most well known lizard in Qatar. It is the second largest lizard living in Qatar and can reach a total length of about 70 cm. The colour of the body changes with body temperature, with bright yellow colour when body temperature is high (37-40°C) and grey dark colour when the body is cold. The colour and design also changes with age. Dhubs are active during the day and live in colonies with some having up to forty individuals. They dig burrows that can be 80 cm deep and more than one meter long depending on soil hardness. Burrows can be separated by a distance of about 10 to 20 meters. Some burrows are shared by the male and female. They are mainly herbivorous and consume at least 58 different plant species in Qatar. They also eat insects and have been seen scavenging. Females lay eggs in burrows



World distribution

This species is present in Egypt, Jordan, southern Syria, Iraq, Iran, the Arabian Peninsula, and the occupied Palestinian territories. It is also present in some islands of the Persian Gulf (Sirri and Hengman). The subspecies living in Qatar, Uromastyx. aegyptia microlepis is also widespread in Saudi Arabia, Oman, Yemen, the United Arab Emirates and Kuwait

Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

This is a well studied species in other countries. We have found 72 international scientific publications about ecology, physiology, behaviour, biogeography and genetics. This is the best studied lizard in Qatar

324

Gas company staff in Ras Laffan collaborating with scientists during the realization of a conservation and scientific project to save the Dhub, and to increase awareness about the importance of these animals in Qatar's ecosystems

325

School students taking measurements of the Dhub. They learn while helping during the scientific campaigns. These are the future scientists of Qatar

326

Measuring bite forces of the Dhub males and females from Qatar to be compared with those from other countries

Arabian toad-head agama
(Phrynocephalus arabicus)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Um Bab

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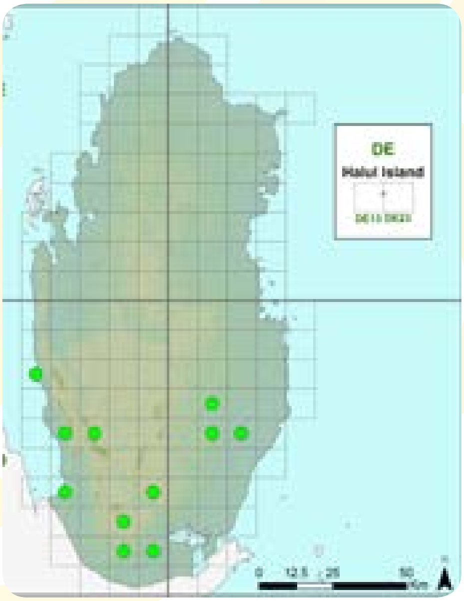
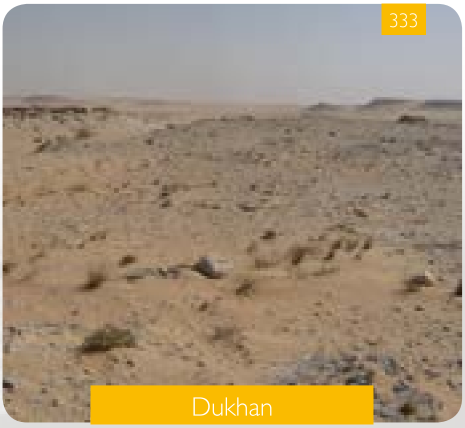
English name: Arabian Toad-head Agama
Scientific name: *Phrynocephalus arabicus*
First description: Anderson, 1894
Family: Agamidae
Synonyms: *Phrynocephalus nejdensis*
Similar species: Not in Qatar

Habitat and Ecology

This is a small lizard with a total length smaller than 20 cm. It has a very special head that looks as though it has armour. The tip of the tail changes to black colour and can coil resembling a scorpion, particularly when they are alarmed. They use this strategy to frighten predators by pretending to be like a dangerous scorpion. This is a diurnal species that can be found in dunes and open sandy areas with vegetation and rocks. They eat insects and other small invertebrates. They use the so-called "sit and wait" hunting strategy and they actively use visual orientation to search for food. Females lay eggs





Dukhan

World distribution

The species ranges from south-eastern Jordan into the Arabian Peninsula, Saudi Arabia, Qatar, United Arab Emirates, Oman and Iran

Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

We have found 19 scientific publications about the species in international databases. Most studies are general about the fauna of Arabia, and few deal with ecology, physiology, osteology, behaviour and parasitology. Some scientists use this species to learn about nanotechnology. No ecological information exists for this species in Qatar

335

Police in Qatar participate and help scientists during the field expeditions, by providing guidance and useful information

336

Exploring artificial structures in the deserts to check for the presence of any lizards. Those places attract lizards that use them for protection against predators and harsh environmental conditions

337

Qatari students from Weill Cornell Medical College learning from scientists in the field

Yellow-spotted agama
(Trapelus flavimaculatus)

338

339

Road to U.A.E

340

341

342

343

English name: Yellow-Spotted Agama

Scientific name: *Trapelus flavimaculatus*

First description: Rüppell, 1835

Family: Agamidae

Synonyms: *Agama flavimaculata*

Similar species: None in Qatar

Habitat and Ecology

This is a medium size lizard with a total length smaller than 30 cm. It shows large variation in body colour from uniform brown to intense blue and red depending on the sex and physiological condition. During the reproductive season males acquire bright intense coloration. They can also change colour very fast when they are alarmed and their head becomes deep blue -this is the reason they are also called "blue headed" agamas. This is a diurnal species that can be found in open rocky areas with vegetation and in sandy areas. They eat insects and other small invertebrates. Females lay eggs

World distribution

The species is distributed in Oman, Saudi Arabia, United Arab Emirates, Yemen and Qatar

Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

We have only found 6 scientific publications about the species in international databases. Most studies are about physiology, and few about genetics and behaviour. No ecological information exists for this species in Qatar

344

Ras Laffan

345

Adult female

346

A team of volunteer students participating during the field surveys in Ras Laffan. Young people need to learn since they are the future leaders of Qatar. In the photo, members of The Youth Company

347

Working on Biodiversity requires a lot of lab and office work in addition to the field work

348

Searching for lizards require a lot of efforts

Schmidt's fringe-toed lizard
(Acanthodactylus schmidti)

349

350

Abu Samra

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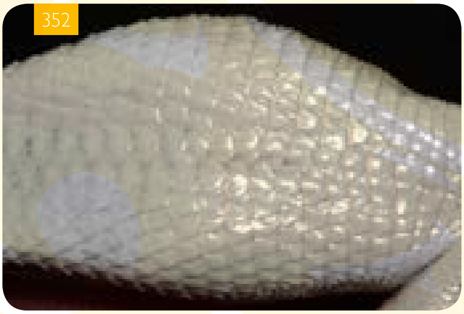


353


354


English name: Schmidt's Fringe-Toed Lizard
Scientific name: *Acanthodactylus schmidti*
First description: Haas, 1957
Family: Lacertidae
Synonyms: *Acanthodactylus cantoris schmidti*
Similar species: *Acanthodactylus scutellatus*

Habitat and Ecology

This is a medium size lizard with a total length smaller than 20 cm. It is active during the day and can be found on sandy vegetated areas, dunes with vegetation and on sabkahs. The species eats insects and other small invertebrates, and makes small burrows where females lay eggs

World distribution

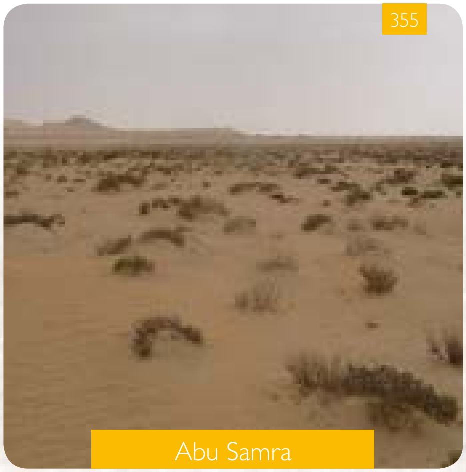
The species is distributed from southern Jordan, south-eastern Iraq and south-western Iran to most of the Arabian Peninsula (Kuwait, Saudi Arabia, the United Arab Emirates, Oman and Qatar). Its type locality is Dhahran (Saudi Arabia)

Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

We have found 23 scientific publications about the species in international databases. Most studies are general and about parasitology, but also about physiology, osteology, ecology and reproduction. No ecological information exists for this species in Qatar



355 Abu Samra

356 Mesaieed

357

Members of the Ministry of the Environment in Qatar and their kids searching for lizards under rocks in the desert

358

Local indigenous knowledge is of great importance for scientists

359

Scientists from Spain, France and United States contributing with the biodiversity surveys in Qatar

Arnold’s fringe-toed lizard
(Acanthodactylus opheodurus)

360

361

Fuwairit

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365


English name: Arnold's Fringe-Toed Lizard
Scientific name: *Acanthodactylus opheodurus*
First description: Arnold, 1980
Family: Lacertidae
Synonyms: Not found
Similar species: Can be mistaken for Acanthodactylus boskianus

Habitat and Ecology

This is a small lizard with a total length smaller than 20 cm. The species has a very long tail, hence why it is also known as the snake-tailed fringe-toed lizard. The species is active during the day and it can be found in sandy areas where there is also vegetation. They eat insects and other small invertebrates. Small burrows are dug near the bushes and females lay their eggs here

World distribution

This species occupies the Arabian Peninsula, Jordan, Iraq, Iran, Qatar and the occupied Palestinian territories. Its type locality is Jazir coast (Oman)

Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

We have found 14 scientific publications about the species in international data bases. Most studies are general about their geographic distribution, and few focus on ecology, physiology, morphology and behaviour. No information about the ecology of the species exists for Qatar

366

Fuwairit

367

Road to the U.A.E

368

We have not found this lizard near irrigated or cultivated areas

369

Meteorological stations in the desert, even if small, are essential to conduct sound ecological studies involving the interactions between animals and climatic conditions

370

Identifying seed and plants to learn about the diet of the Dhub, the only herbivorous lizard in Qatar

Blanford´s short-nosed desert lizard
(Mesalina brevirostris)

371

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Al Aaliya Island

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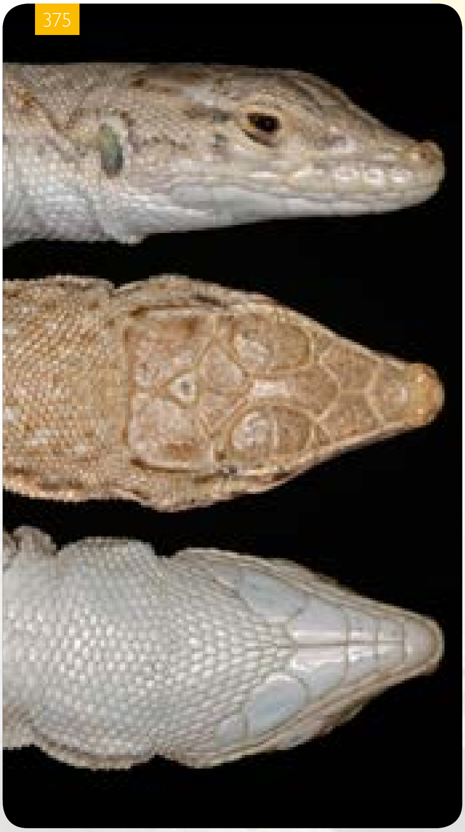


376


English name: Blanford's Short-Nosed Desert Lizard
Scientific name: *Mesalina brevirostris*
First description: Blanford, 1874
Family: Lacertidae
Synonyms: *Eremias brevirostris*
Similar species: Can be mistaken for Mesalina adramitana

Habitat and Ecology

This is a small lizard with a total length smaller than 15 cm lizard that is active during the day. It can be found on hard soils with scrubs and in sandy areas with sparse vegetation. This is present in the mainland and also on the Qatari islands. They eat insects and other small invertebrates. Females lay eggs in burrows

World distribution

The species is distributed from Sinai (Egypt) and south-east Anatolia (Turkey) to Syria and southern Iran; northern Arabian Peninsula, Qatar and Pakistan penetrating into Punjab. Its type localities are Kalabagh (Punjab) and Tumb Island (Arabian Gulf)

Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

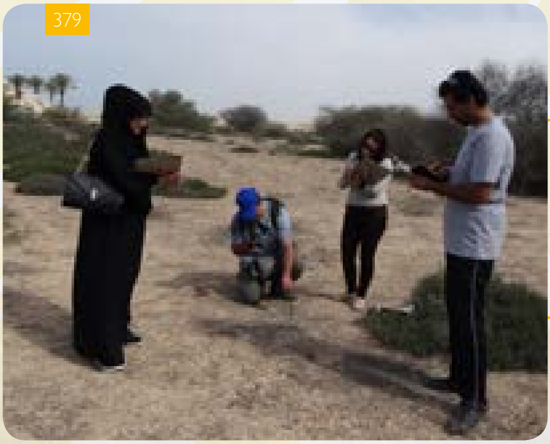
Scientific publications

We have found 13 scientific publications about the species in international data bases. Most studies are general about their geographic distribution, and few focus on physiology and genetics. No information about the ecology of the species exists for Qatar

377
Al Kharrarah

378
Ras Rekan Island

379



Collecting data and information about the lizards

380

Private farms are home of many lizards, and local communities are of great help to scientists aided by students who facilitate translation

381

Searching for lizard clutches in spring time. The eggs need fresh environments to avoid desiccation

Hadramaut sand lizard
(Mesalina adramitana)

382

383

Al-Jassasiya

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English name: Hadramaut Sand Lizard
Scientific name: *Mesalina adramitana*
First description: Boulenger, 1917
Family: Lacertidae
Synonyms: *Eremias adramitana*
Similar species: *Mesalina brevirostris*

Habitat and Ecology

This is a small lizard with a total length smaller than 15 cm. It is active during the day, and can be found on compact sandy soils covered by vegetation. They eat insects and other small invertebrates. Females lay eggs in burrows. The species can be mistaken for Mesalina brevirostris

World distribution

The species is distributed in the Arabian Peninsula, in Saudi Arabia, Qatar, United Arab Emirates, Oman, and South Yemen. Its type locality is Hadramut

Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

This is a poorly known species in the world, and only three scientific publications have been found in international data bases. The studies are general about the distribution of the species. No ecological information about the species exists for Qatar

388

Adult with long tail

389

Al-Jassasiya

390

Collecting and identifying insect biodiversity

391

A scientific team composed by persons of different countries and institutions helps a lot to share knowledge and experiences and improve the final results of the studies

392

Sampling excrements is also essential to learn about the presence of predators in given areas. Their examination also allows identifying the prey eaten by predators

Blandford´s semaphore gecko

(Pristurus rupestris)

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Halul Island

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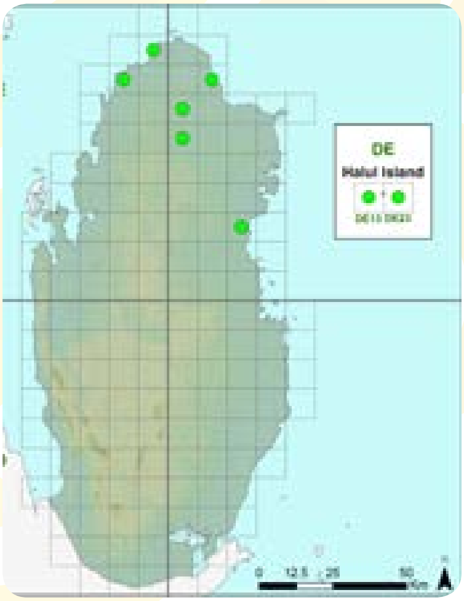
English name: Blandford's Semaphore Gecko
Scientific name: *Pristurus rupestris*
First description: Blanford, 1874
Family: Sphaerodactylidae
Synonyms: *Pristurus flavipunctatus*
Similar species: None in Qatar

Habitat and Ecology

This is the smallest lizards in Qatar, having a total length smaller than 7 cm. It is a diurnal species that occurs in rocky areas, walls of small villages and in abandoned villages. They live in the mainland and also on Halul island. They eat insects and other small invertebrates. Females lay eggs. They are named semaphore geckos because they use their tails to signal to each other and communicate using a variety of tail movements and body postures

World distribution

The species is distributed in the United Arab Emirates, Oman, Saudi Arabia, Qatar, Jordan, Djibouti, Eritrea, Ethiopia, Somalia, and Iran

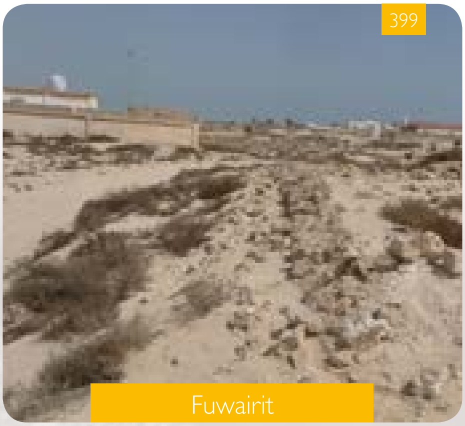


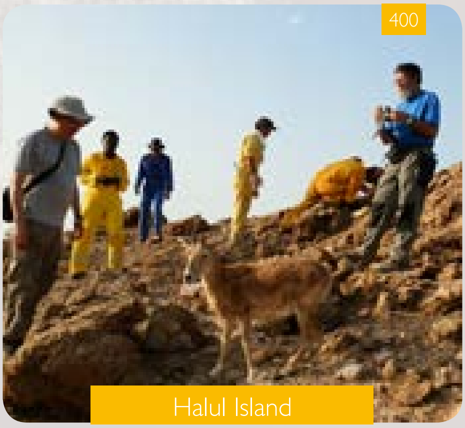
Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

We have found 31 scientific publications about the species in international databases. Most studies are general about their geographic distribution and the description of new records. Other studies focus on ecology, physiology, anatomy, behaviour and parasites. No information about the ecology of the species exists for Qatar


399
Fuwairit


400
Halul Island

401

Old protected villages, such as Al-Jamail Village, are good habitats for lizards where they also find good and fresh places to incubate their eggs

402

Looking for lizards under vegetation requires patience, eye focus, concentration and fast reaction to capture the lizards

403

Recording data is necessary in each study site

Golden grass mabuya
(Trachylepis septemtaeniata)

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Al Wukair

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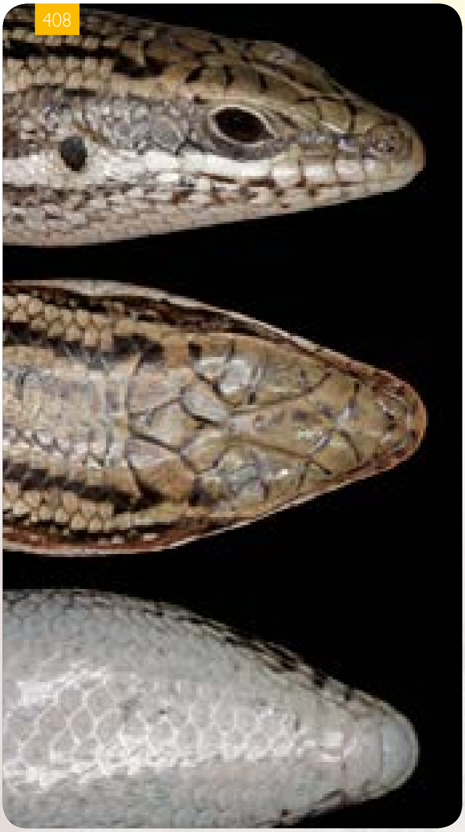


409

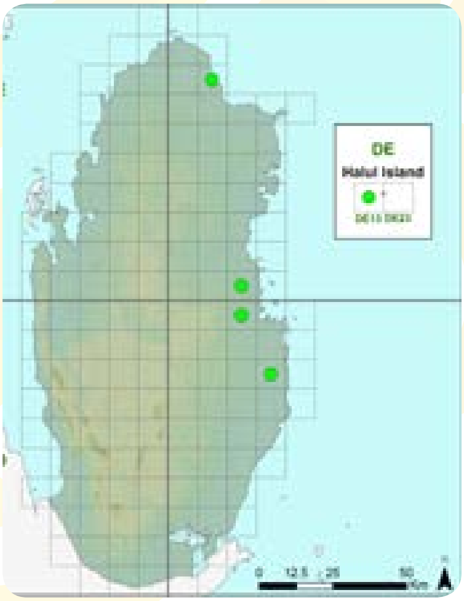

English name: Golden Grass Mabuya
Scientific name: *Trachylepis septemtaeniata*
First description: Reuss, 1834
Family: Scincidae
Synonyms: *Euprepis septemtaeniata*
Similar species: None in Qatar

Habitat and Ecology

This is a medium size lizard with a total length smaller than 30 cm. Their skin is bright and smooth. They are active during the day and can be found mainly in gardens, farms and humanized environments. This is present in the mainland and also in Halul island. They eat insects and other small invertebrates. In the gardens of Qatar Foundation they also eat ice cream from the students. Females lay eggs

World distribution

The species is distributed in Southern Iran, Iraq, Syria, Turkey, Turkmenistan, Nnorth-eastern Saudi Arabia, Bahrain, northern Oman, Eritrea, Afghanistan, and Qatar. Its type locality is Massawa, Eritrea. In Qatar the species is present in the mainland and in Halul island



Conservation status

Scientific publications

Only four scientific publications have been found about the species in international databases, which have been conducted recently between 2006 and 2008 concerning the morphology and taxonomy. No information about the ecology of the species exists for Qatar


410
Fuwairit


411
Halul Island

412

The golden grass Mabuya in Qatar has been only found in gardens and farms

413

Making a book requires handling of a lot of photographs and images and good knowledge of design

414

Surveys have been conducted in all type of habitats. Careful driving is very important in the desert for safety

Eastern skink
(Scincus mitranus)

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Mesaieed

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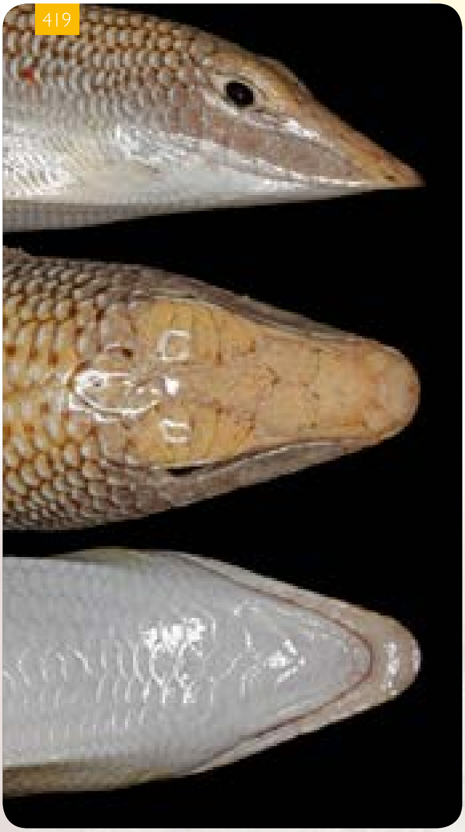


420

English name: Eastern Skink

Scientific name: *Scincus mitranus*

First description: Anderson, 1871

Family: Scincidae

Synonym: *Scincus arabicus*

Similar species: *Scincus scincus*

Habitat and Ecology

This is a medium size lizard with a total length smaller than 30 cm. The skin is bright and smooth. It is active during the day and can be found in sand dunes. They have the ability to "swim" very fast in the sand, which is the reason why they are not easy to see. The snout is shaped like a duck bill to dig easier in the sand. Their legs and tail are short. They eat insects and other small invertebrates. This is the only lizard in Qatar that does not lay eggs. Females are viviparous and give birth to young but fully developed lizards. Eggs can not be safely incubated in the hot and dry sand of the dunes where eggs desiccate and so they benefit from this live birth

World distribution

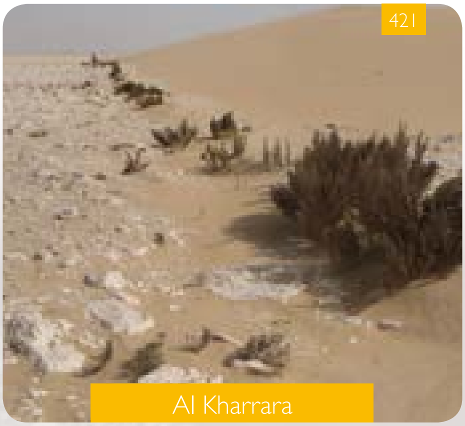
This species is widely distributed in the Arabian Peninsula, western Iran, east of the Asir Mountains and Qatar

Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

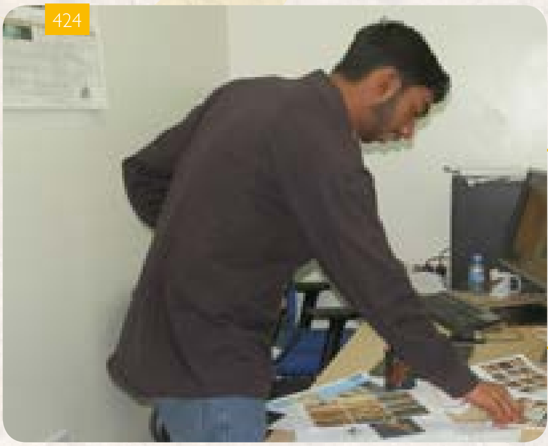
We have found 18 scientific publications about the species in international databases. Most studies are general, about parasites and physiology; others deal with the taxonomy, reproduction and behaviour of these lizards. No information about the ecology of the species exists for Qatar


421
Al Kharrara


422
South Qatar

423

Collecting and identifying plants



424

Qatari student sorting and grouping photos conducted during the field surveys for the identification of the species

425

Exploring insect biodiversity

FOSSORIAL LIZARDS

Diplometopon zarudnyi

Zarudnyi´s worm lizard
(Diplometopon zarudnyi)

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Umm Bab

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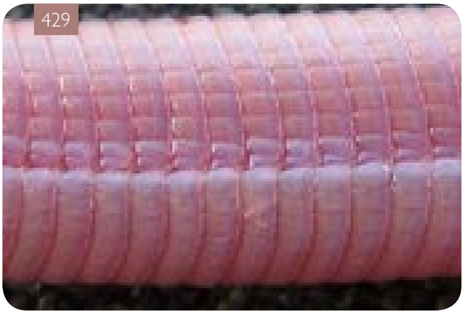

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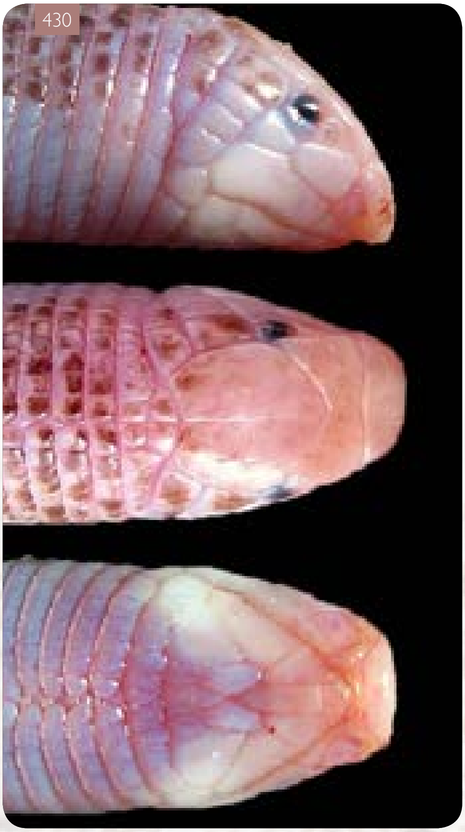

431

Diplometopon tracks

English name: Zarundnyi´s Worm Lizard
Scientific name: *Diplometopon zarudnyi*
First description: Nikolski, 1907
Family: Trogonophiidae
Synonyms: *Diplometopon shueaibi*
Similar species: None in Qatar

Habitat and Ecology

This lizard looks like a worm, and is the reason why it is called the "worm" lizard, but this is a real lizard that has scales like all reptiles. This is the only lizard without legs that lives in Qatar, and moves using body undulations like snakes. The body length is smaller than 30 cm. This is the only Fossorial lizard living in Qatar and its vision is very limited due to their underground life style. The species can be found in soft soils with vegetation and in caves. They eat insects and other small invertebrates. Females lay eggs. The species was very abundant in the past, but now it is a rare species very difficult to see in Qatar

World distribution

The species is distributed in western Iran, southern Iraq and Kuwait, the Arabian Peninsula where it is found in northern and central Saudi Arabia, Oman, the United Arab Emirates and Qatar

Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

We have found 24 scientific publications about the species in international databases. Most of the studies are about physiology and parasites, but also about thermal ecology and behaviour. No information about the ecology of the species exists for Qatar

432

433

Zekreet

434

Sampling plants to study their potential beneficial properties for animal and human populations

435

Soil type influences habitat selection by lizards

436

Installing traps to identify insect biodiversity, the food of lizards

NOCTURNAL LIZARDS

Cyrtopodion scabrum

Bunopus tuberculatus

Pseudoceramodactylus khobarensis

Hemidactylus persicus

Hemidactylus flaviviridis

Hemidactylus robustus

Stenodactylus doriae

Stenodactylus arabicus

Stenodactylus slevini

The moon cycles, the stars and all elements of the sky environment at night are very important for the ecology and behavior of nocturnal lizards, scorpions and other nocturnal species
A Special Astronomy Qatar Project awarded by the QNRF and directed by one editor of this book (Dr Khaled Al Subai) is currently investigating the presence of new exoplanets and other mysteries of the nocturnal sky environment

Rough-tailed gecko
(Cyrtopodion scabrum)

438

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Abu Samra

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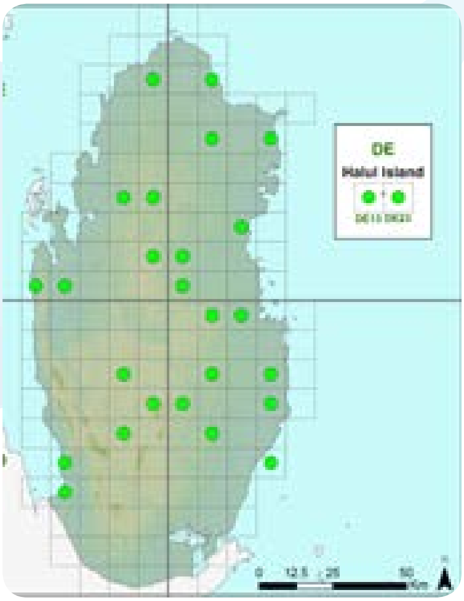
English name: Rough-Tailed Gecko
Scientific name: *Cyrtopodion scabrum*
First description: Heyden, 1827
Family: Gekkonidae
Synonyms: *Gymnodactylus scaber*
Similar species: *Bunopus tuberculatus*

Habitat and Ecology

This is a small lizard with a maximum body length of about 10 cm. The body colour varies according to the colour of the nearest habitat, but is usually brownish grey, with some maroon-coloured patches. The toes are thin and long and lack expanded toe pads, but they can climb high walls and rocks. This species is active at night and during the day it hides in crevices and under rocks. They can be found in almost all habitats in Qatar, but is abundant in humanized sites like gardens, farms, old buildings, artificial wetlands and cities. They eat insects and other small invertebrates. Females lay clutches of one or two eggs several times a year from about April to October. Communal egg-laying sites have been observed in valve pits in Ras Laffan and Qatar Foundation.



World distribution

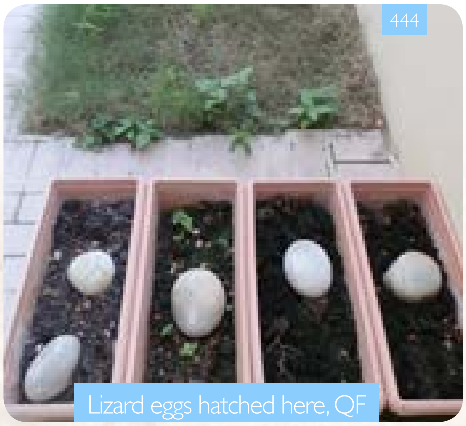
The species in Qatar is present in the mainland and Halul Island. It is present in South-Western Asia and Eastern Africa (Turkey, Egypt, Sudan, Eritrea, Ethiopia, Iran, Pakistan, Afghanistan, India, Iraq, Jordan, Syria, Kuwait, Saudi Arabia, Bahrain, United Arab Emirates, Oman, Yemen and the occupied Palestinian territories. Its type locality is Tor (Sinai, Egypt)

Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

We have found 13 scientific publications about the species in international databases. The studies are quite variable and deal with geographic distribution, physiology, parasites, morphology, genetics and behaviour. No information about the ecology of the species exists for Qatar



444 Lizard eggs hatched here, QF

445 Just hatched

446

Valve pits in Ras Laffan and other areas in Qatar constitute ideal zones for the incubation of eggs of Cyrtopodion scabrum

447

Planning and getting ready before making measurements to the lizards

448

The density of lizards of the species Cyrtopodion scabrum is very high in some areas of Qatar Foundation where large green areas attract many insects that constitute their food. They also consume baby cockroaches, so the lizards contribute to pest control in urban zones

Baluch rock gecko
(Bunopus tuberculatus)

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Simaisma

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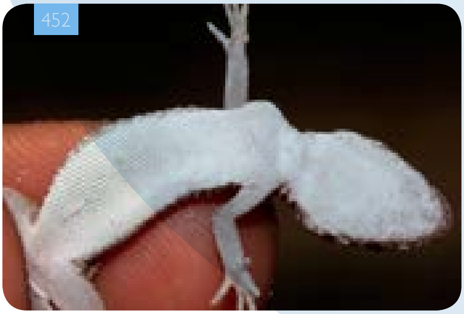

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454

English name: Baluch Rock Gecko
Scientific name: *Bunopus tuberculatus*
First description: Blanford, 1874
Family: *Gekkonidae*
Synonyms: *Bunopus blanfordii*
Similar species: Cyrtopodion scabrum

Habitat and Ecology

This is a small size lizard with a total body length of about 10 cm. The body colour varies according to habitat, usually between brown and grey. The species has prominent tubercles on the back and flanks as indicated by their name "tuberculatus". The toes are rather short and straight and lack expanded toe pads, and they are ground dwelling geckos and do not climb much. They are active at night and during the day they hide in crevices and under rocks. They can be found in stony soils with sparse vegetation and rocks, and in sand fields in rural areas. They eat insects and other small invertebrates. Females lay eggs several times a year

World distribution

This species is distributed in Kuwait, Oman, Saudi Arabia, Qatar, United Arab Emirates, Yemen, Egypt, Jordan, Syria, Afghanistan, Iran, Iraq, Pakistan, Turkmenistan and the occupied Palestinian territories

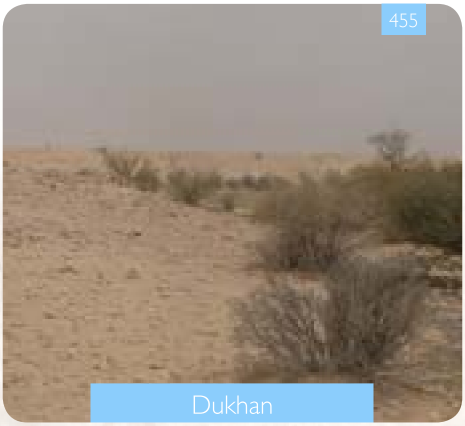
Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

We have found 24 scientific publications about the species in international databases. Most studies are general about their geographic distribution, but also about physiology, particularly dealing with tail regeneration. Other studies are about their parasites and ecology. No information about the ecology of this species exists for Qatar

455



Dukhan

456

Mesaieed

457

People from different institutions are always ready to help

458

Participation of Qatari students during the field survey activities. Training future scientists is very important for the country

459

Asking the opinion and participation of locals is a "must"

Gulf sand gecko

(Pseudoceramodactylus khobarensis)

460

461

Al-Saflia Island

New to Qatar!


462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English name: Gulf Sand Gecko
Scientific name: *Pseudoceramodactylus khobarensis*
First description: Haas, 1957
Family: Gekkonidae
Synonyms: *Stenodactylus khobarensis*
Similar species: *Stenodactylus slevini* and *Stenodactylus doriae*

Habitat and Ecology

This is a new species to Qatar that was first discovered in two islands near Doha in spring 2013. It is a small lizard with a total length smaller than 15 cm. It is characterized by the absence of dorsal tubercles. The toes are moderately fringed and lack expanded pads. It is active at night and during the day it hides under rocks. They can be found on soils with sparse vegetation and rocks. It is also present in coastal areas and salty habitats. It is present in the mainland and in Qatar islands. The species eat insects and other small invertebrates. Females lay eggs

World distribution

This species is distributed in Arabian Gulf countries, including Iran, Kuwait, Saudi Arabia, Bahrain, United Arab Emirates, Oman and Qatar. Its type locality is Al Khobar, Saudi Arabia

Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

This is a poorly studied lizard in the world with only four scientific publications found about the species in international databases. Three of the studies describe the presence of the species in new geographic localities, one of them in Qatar; and one study is about osteology. No information about the ecology of the species exists for Qatar

466

Al Aaliya Island

467

Al Aaliya Island

468

Trip to Al-Saflia island in the boat of the Ministry of Environment to survey lizard populations

469

The Socotra cormorant is also present in the islands occupied by this gecko species

470

The Gulf sand gecko can be found very near to the beach in Al Aaliya island

Persian Leaf-Toed Gecko

(Hemidactylus persicus)

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472

Halul Island

New to Qatar!

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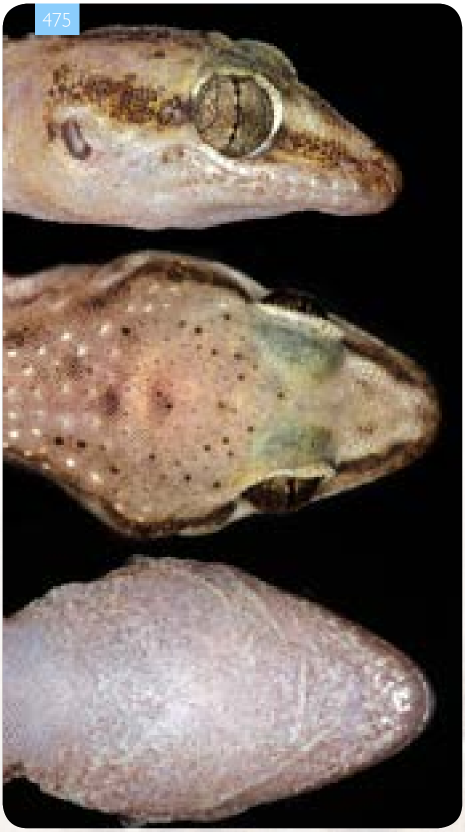

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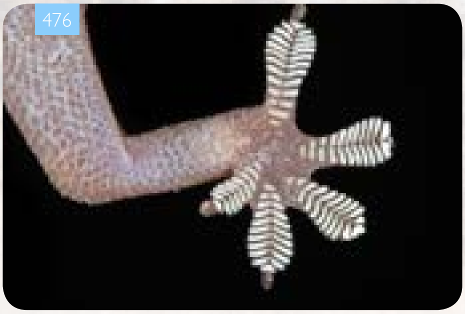

English name: Persian Leaf-Toed Gecko
Scientific name: *Hemidactylus persicus*
First description: Anderson, 1872
Family: Gekkonidae
Synonyms: *Hemidactylus bornmuelleri*
Similar species: *Hemidactylus robustus*

Habitat and Ecology

This is a new species to Qatar that was discovered on Halul island in spring 2013. To date it has not been found in any other zone of Qatar. This is a small lizard with a total length smaller than 15 cm. They have adhesive pads in their toes to improve climbing trees and walls. This is a nocturnal species and during the day it hides under rocks, vegetation and crevices and is difficult to locate. It is present on hard stony soils with bushes and in gardens with ornamental trees and vegetation in humanized habitats. The major predators in Halul island are birds and cats that were introduced by man. The lizard eats insects and other small invertebrates. Females lay eggs

World distribution

The species occurs in Iran, Iraq, Pakistan, India, northeast Saudi Arabia, Kuwait, Bahrain, the UAE and Qatar. Its type locality is in Persia.

Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

We have found 33 scientific publications for this species in international databases. Most studies are general about their geographic distribution and description of new records. Others focus on ecology, physiology, osteology and behaviour. No information about the ecology of the species exists for Qatar


477

Halul Island


478

Halul Island

479

The staff from Qatar Petroleum helping during the field surveys in Halul island

480

Lab work is needed to morphologically characterize and differentiate the species. Qatari student collaborating with the research activities in the laboratories of College North Atlantic, Qatar (QEERI-QF)

481

High resolution cameras are essential to get photos of the animals in their natural habitats

Yellow – Bellied house gecko
(Hemidactylus flaviviridis)

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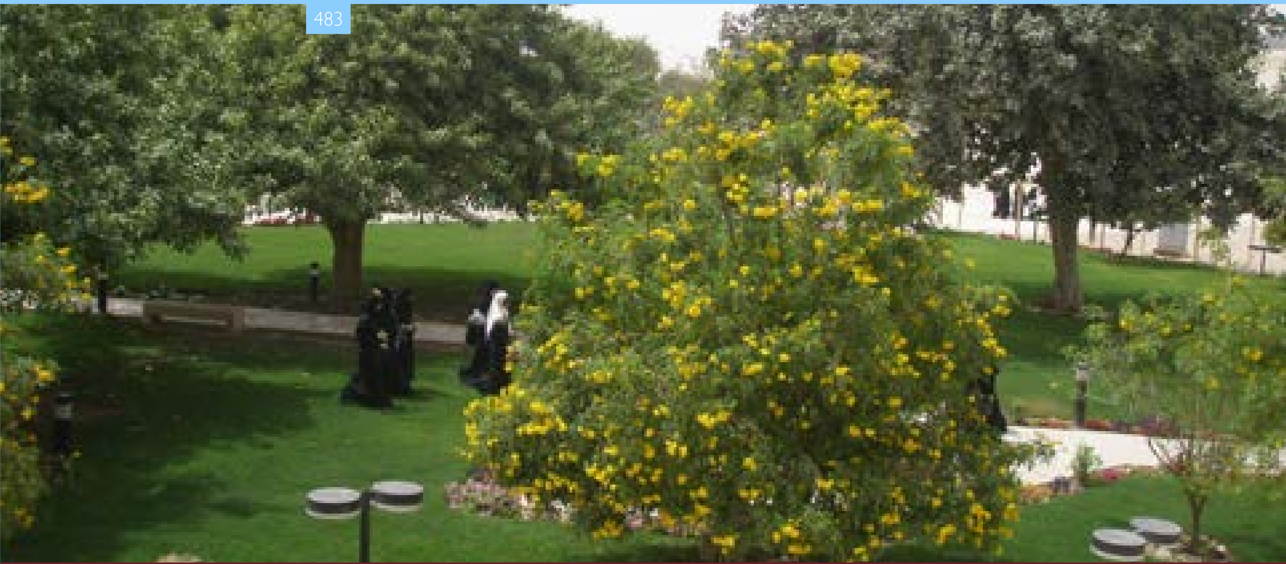

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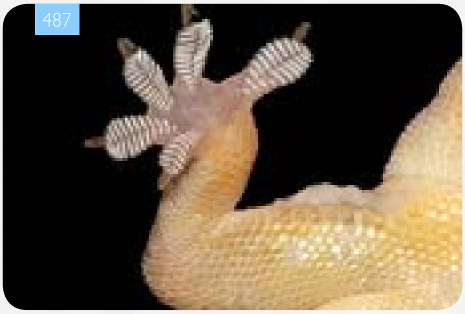

English name: Yellow-Bellied House Gecko

Scientific name: *Hemidactylus flaviviridis*

First description: Rüppell, 1835

Family: Gekkonidae

Synonyms: Not found

Similar species: None in Qatar

Habitat and Ecology

This is a medium size lizard with a total length smaller than 20 cm. The species shows large variation in body colour from pale greyish to dark brown or grey. It is active at night and climb walls and ceilings exceptionally well, thanks to the adhesive pads present in their toes. During the day it hides in crevices and is difficult to locate. It can be found mainly in humanized environments and old abandoned villages. They live on the mainland and also on Halul island. The species eat insects and other small invertebrates. They consume baby cockroaches living in houses and gardens at very high speed, such as 8 individuals in 17 seconds. Females lay eggs

World distribution

This species is distributed in Saudi Arabia, United Arab Emirates (UAE), Oman, Socotra Island (Yemen), Egypt, Sudan, Somalia, Ethiopia, Eritrea, Iraq, Iran, Afghanistan, Nepal, Pakistan, India and Qatar

Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

Of all lizard species living in Qatar, this is the best studied by the international community. We have found 424 international scientific publications. Many studies have been conducted on the physiological aspects of this species, but also about its ecology, behaviour, biogeography and genetics. However, no studies about this species have been conducted in Qatar

488

Female and egg

489

Ras Laffan

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Maps are essential and very important to conduct biodiversity research

491

Laboratory in Weill Cornell Medical College, Qatar, where a lot of lab work has been conducted to examine the diet of the Dhub

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Lizards can live on extreme dry soil

Heyden's Gecko
(Hemidactylus robustus)

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Al Aaliya Island

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English name: Heyden's Gecko
Scientific name: *Hemidactylus robustus*
First description: Heyden, 1827
Family: Gekkonidae
Synonyms: *Hemidactylus turcicus parkeri*
Similar species: *Hemidactylus persicus*

Habitat and Ecology

This is a small lizard with a total body length of about 10 cm. It is strictly a nocturnal species. During the day it hides in crevices and under rocks. They live in the mainland and also on Qatar islands. They can be found in stony soils with sparse vegetation and rocks, and also in humanized habitats. It has excellent abilities to climb vertical surfaces thanks to the adhesive pads present on their toes. They eat insects and other small invertebrates. Females lay eggs. It is frequently mistaken for other lizard species (*Hemidatylus turcicus*) that do not live in Qatar

World distribution

This species is distributed in Egypt and Sudan (Red Sea coast); Eritrea, Ethiopia, Somalia, Kenya; Arabian Peninsula, Qatar, Iraq, coastal Iran and Pakistan and Yemen and Qatar

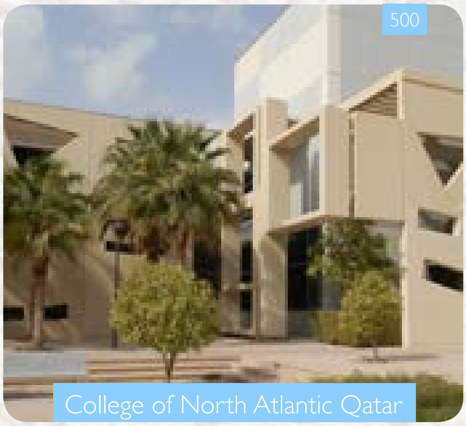
Conservation status

It is classified as Least Concern (LC) on the IUCN Red List

Scientific publications

We have found 13 scientific publications about the species in international databases. All of them are related to their geographic distribution and the description of new species or records for new locations. No information about the ecology of the species exists for Qatar

499
Al Aaliya Island



500
College of North Atlantic Qatar

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Scientists and Qatari experts from the Ministry of the Environment in Qatar working in Al Aaliya island

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Mixing cultures and knowledge greatly improves biodiversity work and the conservation of the environment

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Locals at farms in Qatar are extremely friendly and helpful

Middle Eastern Sand Gecko
(Stenodactylus doriae)


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Saudi border

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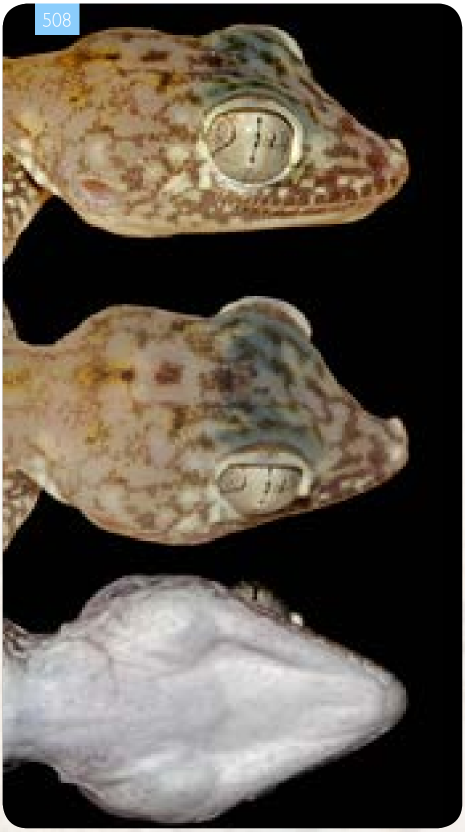


509

English name: Middle Eastern Sand Gecko
Scientific name: *Stenodactylus doriae*
First description: Blandford, 1874
Family: Gekkonidae
Synonyms: *Ceramodactylus major*
Similar species: *Stenodactylus slevini*

Habitat and Ecology

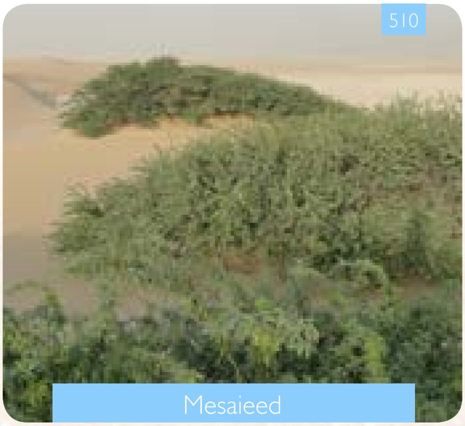
This is a small lizard with a total length smaller than 15 cm. It is quite a colourful gecko showing pinkish skin with yellow and dark reticules, but without dorsal tubercles. The toes of the forefeet are fringed but they have not adhesive pads in their toes. They do not climb vertical surfaces but are strictly ground dwelling geckos. This is a nocturnal species, during the day it hides in burrows. They can be found in vegetated sandy habitats. They eat insects and other small invertebrates. Females dig burrows in the sand to lay the eggs

World distribution

This species ranges from south-western, southern and eastern Jordan into Saudi Arabia, the United Arab Emirates, Qatar, Yemen, Oman, Iraq, Iran and the occupied Palestinian territories

Scientific publications

We have found 15 scientific publications about the species in international databases. Most studies are general and about their geographic distribution.Few studies focus on ecology, osteology, tail regeneration and genetics. No information about the ecology of the species exists for Qatar



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Mesaieed

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Al Kharrara

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International team ready for the biodiversity mission

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Getting information from the locals is very important

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Collecting scientific data using standard forms

Arabian sand gecko
(Stenodactylus arabicus)

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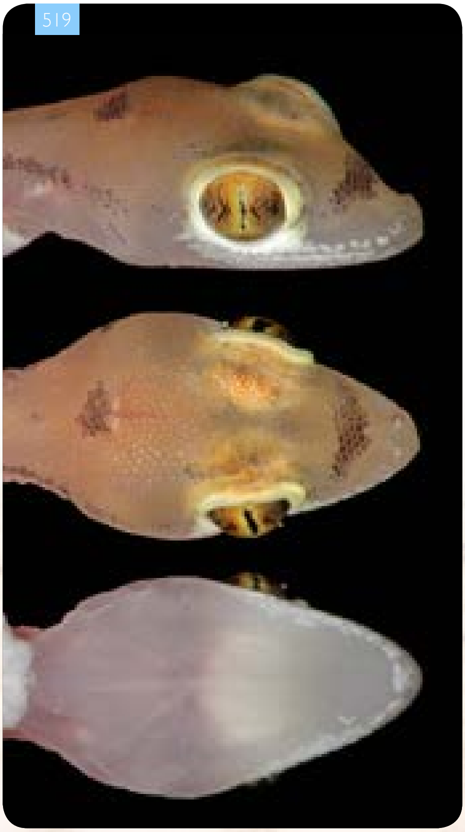

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English name: Arabian Sand Gecko
Scientific name: Stenodactylus arabicus
First description: Haas, 1957
Family: Gekkonidae
Synonyms: *Trigonodactylus arabicus*
Similar species: None in Qatar

Habitat and Ecology

This is a small lizard with a total length smaller than 15 cm. It has semitransparent pinkish skin and lacks dorsal tubercles. It has characteristic triangular fringed fingers, and they do not have adhesive pads on their toes. This species is a strictly ground dwelling gecko that does not climb vertical surfaces. It is a nocturnal species, and during the day it hides in burrows or under rocks. They can be found in dunes and sandy vegetated habitats. They eat insects and other small invertebrates. Females dig burrows in the sand to lay eggs

World distribution

This species is present in Kuwait, Saudi Arabia, Qatar, southern and central Oman and the United Arab Emirates Bahrain

Scientific publications

We have found 8 scientific publications about the species in international databases. All the studies except one are about their geographic distribution and the discovery of new records. The other study concerns parasites in this species. No information about the ecology of the species exists for Qatar


521
Al Kharrara


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Abu Samra

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Team discussion to carefully organize the field surveys

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Catching newly hatched young lizards under stones by members of the Ministry of the Environment and Qatar Foundation

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The data collected in the field have to be added to databases for scientific research

Slevin's short-fingered gecko
(Stenodactylus slevini)

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Fuwairit


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English name: Slevin´s Sand Gecko
Scientific name: *Stenodactylus slevini*
First description: Haas, 1957
Family: Gekkonidae
Synonyms: *Stenodactylus arabicus*
Similar species: *Stenodactylus doriae*

Habitat and Ecology

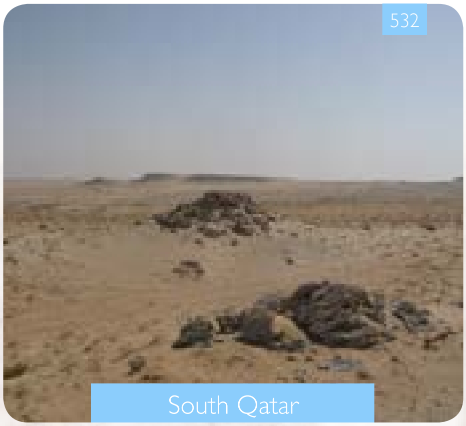
This is a small lizard with a total length smaller than 15 cm. It is a very colourful gecko without dorsal tubercles but with yellow/orange colours on the dorsal side of the body. It does not have adhesive pads present in their toes. This is a strictly ground dwelling lizard species that does not climb vertical surfaces. It is a nocturnal gecko and during the day they hide under rocks. It is found in hard substrates with stones and compact sand, and near sandy vegetated habitats. It eats insects and other small invertebrates. Females dig burrows in the sand to lay the eggs

World distribution

This species has been recorded from north-western Saudi Arabia, Bahrain, Qatar, southern Iraq, United Arab Emirates, Jordan and Yemen

Scientific publications

We have only found 7 scientific publications about the species in international databases. Most studies are about their geographic distribution and the discovery of new records, and also about osteology and physiology. No information about the ecology of the species exists for Qatar



532 South Qatar

533 Dukhan

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Qatari students at the College of the North Atlantic (QEERI-QF) searching for international references and information about the Qatari lizards

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Marking trees with temporal labels is needed to easily identify them during multiple surveys across time

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Conducting lab work in the field

VII
OTHER LIZARD SPECIES POTENTIALLY PRESENT IN QATAR

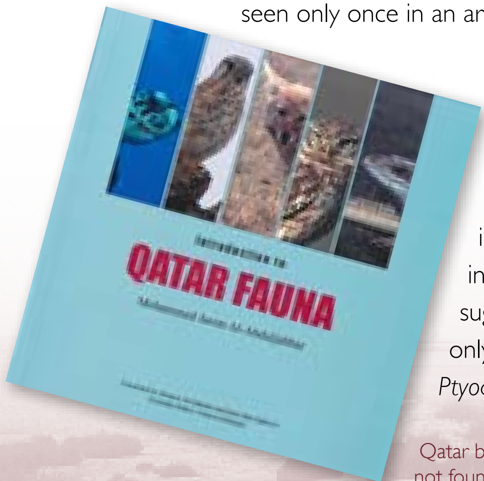
Other lizard species potentially present in Qatar

In this chapter we provide the names, photos, and distribution maps of some lizard species that could potentially be in Qatar even if we did not encounter them during the most recent field surveys conducted in 2012 and 2013.

A recent study using estimators of species richness indicates that the lizard inventory seems to be nearly completed for Qatar (Cogălniceanu et al. 2014). However, the same authors also suggested that it would be not surprising to find additional lizard species in Qatar, specifically, species known to occur in the vicinity of Qatar. In fact, the maps provided in Sindaco and Jeremčenko (2008) show that 13 lizard species are present near Qatar: *Ptyodactylus hasselquistii*, *Teratoscincus keyserlingii*, *Phrynocephalus maculatus*, *Pseudotrapelus* sp., *Trapelus ruderatus*, *Trapelus pallidus*, *Chalcides ocellatus*, *Scincus scincus*, *Acanthodactylus boskianus*, *Acanthodactylus haasi*, *Acanthodactylus gongrorhynchatus*, *Acanthodactylus scutellatus*, and *Mesalina guttulata*.

Considering the information provided in the literature for the Qatar herpetofauna (Mohammed 1988, Al-Abduljabbar 2011), six more lizard species should occur in Qatar, in addition to the 21 species listed in the recent study by Cogălniceanu et al. (2014), which are described in the present book (Chapter VI). The five lizard species described for Qatar by Mohammed (1988) that were not seen during the recent surveys are *Acanthodactylus scutellatus*, *Acanthodactylus boskianus*, *Scincus scincus*, *Chalcides ocellatus*, and *Pseudotrapelus sinaitus*. The species *Scincus scincus* has been seen again in spring 2013 in Alwakra (East Qatar) by experts of the company AECOM (Anthony Eland, pers.com.). However, it was seen only once in an area that is currently under construction.

In the book of Al-Abduljabbar (2011), the author shows a photo of a lizard of the genus *Phytodactylus*, which is easyly recognizable by its typical finger morphology. Even if the scientific name was listed erroneously as *Hemidactylus flaviviridis*, it is important to consider that a *Ptytodactylus* was seen in Qatar. Considering the distribution maps and the suggestions of Sindaco and Jeremčenko (2008), the only species of this genus that could likely be in Qatar is *Ptyodactylus hasselquistii*.



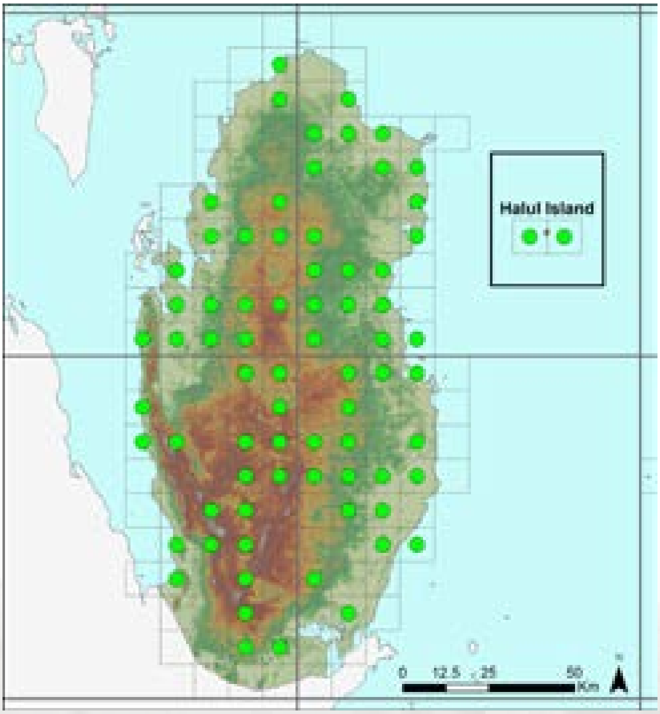
Qatar book including the presence of some lizard species that were not found during the recent surveys

Perhaps some of the lizard species described as present in Qatar by previous authors have been mistaken for other similar species, as suggested in a recent study (Cogălniceanu et al. 2014). This could explain why those species were not encountered during our surveys, and also why the species encountered during our surveys were not described.

However, considering the world distribution range of the lizard species, they could certainly be part of the Qatar fauna. Thus, it is prudent to accept that the lizard species described as present in Qatar by the different authors cited above is correct. It is then our responsibility to find them in the Qatar territory, identify them properly, make detailed photographs, and register the GPS locations where the individuals of those species are currently living. We need to determine if those species could have become rare or even extinct in Qatar, or not.

In any case, we are aware that our field surveys are not complete. In the Qatar Peninsula there are 149 grid squares of 10x10 km, but we only surveyed approximately half of them (48%, of the squares, n=72). Also, many of the squares have been visited only once. Thus, it is quite likely that the "missing" species may still be found in Qatar.

We encourage students and the general public to help scientist to discover these species and report their presence to the authorities at the Ministry of the Environment in Qatar. Doing so will increase the list of lizard species for the country and improve the current status of the Biodiversity Qatar National Data Bases.



Map of Qatar showing the square grids that have been surveyed in 2012 and 2013 (green dots)

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Phrynocephalus maculatus

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Pseudotrapelus sp

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Trapelus mutabilis

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Trapelus ruderatus


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Acanthodactylus boskianus


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Acanthodactylus grandis


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Acanthodactylus scutellatus


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Mesalina guttulata

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Scincus scincus

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Chalcides ocellatus

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Ptyodactylus hasselquistii

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Teratoscincus scincus

VIII
THREATS TO LIZARDS IN QATAR

Threats to lizards in Qatar

Qatar is rising rapidly in population number and density, and its massive urban, industrial and infrastructure growth increasingly threatens and depletes the nation's biodiversity. Qatar produces around two million tons of solid municipal waste annually, corresponding to a daily generation rate of about 2.5 kg per capita that is disposed of mainly through landfill and composting. This increase in solid waste generation not only results in environmental pollution but also habitat destruction (Al-Maaded et al. 2012).

Apart from global warming, the lizards of Qatar are threatened in many other ways. The rapid human population growth, increasing from several tens of thousand inhabitants to almost two million in the last century, has caused high levels of habitat destruction due to construction development, gas and oil extraction, and the development of transport facilities. Overgrazing by ungulates has depleted most of the natural vegetation. Pest insects contribute to the decline of many trees and plants, which are very important as food, and for appropriate thermoregulation. The introduction of alien species and the proliferation of cats have major negative impacts on lizard populations. Hunting Dhubs, even if the practice has been reduced nowadays, has a negative effect on Dhub populations as well.

Global warming

Global warming and climate change threaten the lizard biodiversity in Qatar both directly and indirectly. Most lizards cannot sustain activity at very high environmental temperatures. Moreover, developing embryos during incubation require low soil temperatures (Castilla 1996, Castilla & Swallow 1996) otherwise hatching success decreases or fails. Especially in desert-adapted species, lizards are operating near the limits of their thermal maxima. Thus, even slight increases in ambient temperature may have devastating effects on the survival of these animals.

The effect of temperature changes on lizards is also present in an indirect way through the effects this may have on their food. Insects are the main food source for most lizard species, and insect cycles and insect survivorship are also affected by environmental temperatures (Kareiva et al. 1993). Most insects rely on vegetation to survive, and plants depend on rainfall and appropriate conditions to grow and survive in the desert. Thus, even if lizards could manage and adapt to live under higher environmental temperatures, they cannot survive without a source of food. Many terrestrial animals (vertebrates and invertebrates) living in extreme arid areas where food resources are depleted inland, in many cases move to the coast to find food of marine origin where they scavenge on carcases of sea birds and other marine fauna (Castilla et al. 2008, Castilla 2009). Thus, the coastal zones in Qatar also require protection as these areas may be important places to sustain wild populations of some lizard species.

Overgrazing

Overgrazing by camels, goats and sheep is another major environmental problem in Qatar (Richer 2008). It has been a common practice to allow these animals to openly graze rather than within confined pens. This grazing pattern has largely depleted the vegetation that existed in Qatar. The losses include the decrease of vegetation density and are linked to the local extinction of some plant species (Bari 2012). The reduction in vegetation has also reduced animal life depending on plants, has increased soil erosion through the effect of the wind, and caused a decrease in soil fertility.

Qatar has the highest density of camels (*Camelus dromedarius*) in the Middle East and the third highest amongst surveyed North African countries (Richer 2008). Other grazing ungulates in Qatar include domestic goats (*Capra aegagrus hircus*) and sheep (*Ovis aries*). Qatar is home to approximately 10,000 horses; 14,000 cattle; 50,000 camels; and 370,000 sheep and goats (Ministry of Environment, personal communication).

Competition for plants between herbivorous lizards (e.g., the Dhub) and livestock can threaten the populations of lizards living near farms (Cunningham 2000). Conservation measurements related to livestock management have to be implemented by the Ministry of the Environment in Qatar.

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Overgrazing has largely depleted the vegetation that existed in Qatar

Habitat destruction

The human impact in Qatar is particularly high around large urban areas, but it is also noticeable along the coast and the interior due to increasing numbers of roads and construction sites. High traffic on roads, particularly in rural areas, can result in high mortality of reptile populations (e.g. Shepard et al. 2008). Road-kills are frequent and while it is difficult to document small lizards affected by this, carcasses of larger lizards like *Uromastyx aegyptia* are often found along roads.

Overall, human impact in Qatar represents a major threat for the survival of the sparsely and locally disseminated lizard populations, usually with very low population densities. We estimate that human activities will result in changes in the ranges of the lizards of Qatar and stress the urgent need for a complete species inventory and mapping, as a background study for a future monitoring program.

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The human impact is high around urban areas and in the desert due to increasing roads and construction activities

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Some lizards are intentionally killed, others get trapped in artificial containers and die unless they are found and rescued. Management is needed to prevent such loses, and the Ras Laffan team of experts have contributed a lot to reduce lizard mortality in the NE Qatar

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Lizards like basking near roads

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Traffic on roads results in high mortality of lizards

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Garbage damps constitute a serious danger for animals. Many lizards and invertebrates get trapped inside the bottles and die

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Conducting intense and long term campaigns of education and social awareness is the only way to teach and educate the people to be responsible with the Qatar natural environment

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IX
FUTURE DIRECTIONS

Future directions

This is the first comprehensive book that has ever been published worldwide on the lizards of Qatar and shows the first distribution maps for the Qatar lizards. The book also makes scientific biodiversity data available for Qatar, the Gulf region and the international community. However, a lot of work is still needed to finalize the distribution maps, to better understand even the most basic aspects of the biology and ecology of the lizards, to identify conservation priorities for each species, and to establish future monitoring programs. This will enable modelling of lizard species distribution at a local, regional and global scale in order to allow for predictions of species range shifts under different climate change scenarios and under different human impact factors.

Scientific research is needed to acquire sound and unbiased data that can help to determine zones of conservation interest including the areas with high species richness and high levels of rarity.

Providing unbiased scientific information is the only way to help governmental and other stakeholders tackle critical environmental issues. Training rangers and students is essential to equip them with the necessary skills to become excellent environmental agents and future scientists to improve management and conservation of biodiversity in Qatar.

Below we provide a list of activities that should be conducted to improve the management and conservation of lizard and other wild species in Qatar:

- Complete the catalogue of lizard species present in Qatar including the protected and private areas and all the islands
- Finalize the distribution maps of lizards in Qatar
- Conduct scientific research to gather information about the most basic aspects of the biology and ecology of lizard species in Qatar that are still unknown
- Understand the habitat requirements and vulnerabilities of each lizard species
- Determine zones of important conservation interest for lizards in Qatar
- Promote the continuous combination of field and laboratory work
- Conduct genetic DNA studies to ensure the correctness of the taxonomic classifications
- Document the presence of introduced species that may compete with local species and contribute to the demise of local indigenous populations or originate the extinction of autochthonous species
- Control the population of alien predators
- Identify conservation priorities for each species
- Establish protection laws for each species separately
- Improve the conservation of lizards, their food resources and their habitats in Qatar
- Establish continuous monitoring programs of the interactions between predators and prey in natural populations

- Modelling lizard species distribution at local, regional and global scale in order to allow for predictions of lizard species range shifts under different climate change scenarios and under different human impact factors
- Upload the lizard distribution information to the Global Biodiversity Information Facility (GBIF) to make Qatar biodiversity data available and useful for the international community
- Explore the impact that climate change and other human activities may have on the habitat and survivorship of lizard species
- Recommend a ban of hunting the Dhub in natural populations
- Consider the creation of a Dhub farm in Qatar for food and hunting purposes
- Identify ways to ameliorate the effect of human activities on wild populations and the Qatar ecosystem
- Identify and examine all biodiversity documents that have been conducted over time in Qatar and which are scattered in different institutions
- Encourage the inclusion of historical and current research/ documentation in local reports and promote the publishing of research papers in international journals
- Increase the level of involvement of the Qatari students and the general public in participative science

Protecting the environment and the interactions among all living creatures is one of the responsibilities in the Ministry of Environment of Qatar

- Establish biodiversity training programs for rangers and students
- Promote master´s programs in the direction of conservation of biodiversity in Qatar
- Improve campaigns of social awareness to promote conservation of biodiversity in Qatar
- Maintain and increase the levels of institutional participation inside Qatar. Team work is essential for the successful conservation of biodiversity
- Maintain and increase the levels of international participation to improve scientific research and the international visibility of Qatar
- Provide scientific information to help governmental and other stakeholders tackle critical environmental issues
- Encourage well structured and organised meetings with clear, measurable outputs that lead to direct actions being taken, and which can be monitored over time

Qatar's National Vision (QNV) 2030 rests on four pillars including Human Development, Social Development, Economic Development, and Environmental Development. The conservation of biodiversity in Qatar is also aligned with the Qatar National Development Strategy 2011-2016 included in the research area of Energy and Environment "Understanding and Protecting the Natural Environment" with the goal "Biodiversity and Environmental Restoration".

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Our responsibility and our message to society are to respect wildlife and the Qatar environment (His Excellency Ahmad Bin Amer Mohamed Al Hemaidi, Minister of Environment, Qatar)

X
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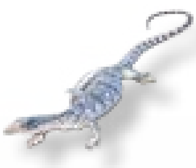

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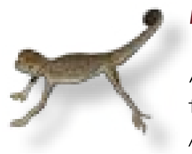

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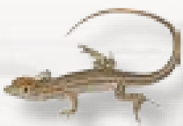

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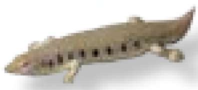

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